This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

THE WORLD'S EPOCH-MAKERS

EDITED BY

OLIPHANT SMEATON

William Herschel and His Work

By James Sime, M.A., F.R.S.E.

PREVIOUS VOLUME IN THIS SERIES:—

Buddha and Buddhism.

By Arthur Lillie.

For List of Volumes already issued and in preparation see end.

THE WORLD'S EPOCH-MAKERS

William Herschel

and His Work

By

James Sime, M.A., F.R.S.E.

"The life of Herschel had the rare advantage of forming an epoch in an extensive branch of astronomy."

Arago

Edinburgh. T. & T. Clark

1900

THE NEW YORK
PUBLIC LIBRARY
917154A
ASTOR, LENOX AND
TILDEN FOUNDATIONS
R 1937 L

Reference copy / 20467G.

PRINTED BY
MORRISON AND GIBB LIMITED,
FOR
T. & T. CLARK, EDINBURGH.
LONDON: SIMPKIN, MARSHALL, HAMILTON, KENT, AND CO. LIMITED.
NEW YORK: CHARLES SCRIBNER'S SONS.
TORONTO: THE PUBLISHERS' SYNDICATE LIMITED.

NEW YORK
PUBLIC
LIBRARY

PREFACE

To present to the public the life and work of a man who powerfully influenced the progress of astronomy a century ago, and stamped on his own age as well as ours a loftier view of Creation and its Author than was ever before entertained, may be best done by allowing him and his contemporaries to tell their own story, and to relate their own impressions. We all prefer to hear them speaking, to see them playing their parts in life, and to watch the drama of surprise, wonder, and criticism unfolding itself in their written or printed pages. If I have succeeded in my endeavour to tell the story on these lines, I shall have attained the end which I had in view when I undertook this work.

William Herschel was not a mathematician of the order of Newton, Laplace, or even of his own son. He made no pretence to that high honour. His fields of research were much simpler, though not less laborious, and the harvests he reaped were enjoyed by mankind without a strain on the understanding which very few in any age are capable of. A popular exposition of his career and his discoveries in the light of more

recent triumphs may be as easy to follow now, and as welcome as it was in his own day.

What Sir William and Lady Huggins recently said of their own labours with the spectroscope, Herschel could have said a century before of the difficulties his sister and he encountered and overcame with the telescope: "It is scarcely possible at the present day, when all these points are as familiar as household words, for any astronomer to realise the large amount of time and labour which had to be devoted to the construction of the first star spectroscope."[1]

[1] *Atlas*, 1899, p. 8.

CONTENTS

CHAP.		PAGE
I.	THE FAMILY	1
II.	THE EDUCATION	10
III.	IN ENGLAND	21
IV.	THE DISCOVERY OF HERSCHEL	45
V.	THE DISCOVERY OF URANUS	66
VI.	ENDOWMENT OF RESEARCH	83
VII.	THE GREAT TELESCOPE	106
VIII.	"THE CONSTRUCTION OF THE HEAVENS"	128
IX.	THE SUN	155
X.	PLANETS AND COMETS	167
XI.	HERSCHEL'S ENGLISH HOME	195
XII.	DOUBLE STARS AND NEBULÆ	218
XIII.	THE SURVIVOR	238
	APPENDIX	257
	INDEX	263

WILLIAM HERSCHEL AND HIS WORK

CHAPTER I

THE FAMILY

CICERO in his exquisite little book, written two thousand years ago in the infancy of astronomy, and called *Scipio's Dream*, delighted the Roman world of his day with stories of the stars, which were a mixture of romance and truth. He formed some idea of their movements from a rough approach that had been made even then to a globe of the heavens, and he filled his readers with awe at the music which was believed to accompany their passage through space. The music of the spheres has passed into our language and our thoughts at the present day. But it would have been the greatest wonder of all could Cicero have foreseen that, more than nineteen centuries after his day, the true music of the spheres and the truest means of hearing it sung would be discovered by the genius, the almost unaided genius, of "a philosopher without the rules," a musician in the town of Bath, then a haunt of savages or wild beasts. He was organist in the Octagon Chapel of that city, the director of

concerts and balls in a "rendezvous of the diseased," where "ministers of state, judges, generals, bishops, projectors, philosophers, wits, poets, players, fiddlers, and buffoons" met and trifled, amid "dressing, and fiddling, and dancing, and gadding, and courting, and plotting." But so it was; and never were men and pursuits so unlike brought face to face, or placed side by side in the business of life.

When "the music and entertainments of Bath were over for the season," and "when not a soul was seen in the place but a few broken-winded parsons, waddling like so many crows along the North Parade, great overgrown dignitaries and rectors, with rubicund noses and gouty ankles, or broad bloated faces, dragging along great swag bellies, the emblems of sloth and indigestion," this pleasant-faced director of concerts and oratorios, this man of smiling look and noble bearing, wearied out with the music of the season, sought rest and refreshment in a constant and devoted study of the higher music of the heavens. He had none to help him but a younger sister, who was unwillingly dragged from the concert-room and the theatre to less congenial pursuits, and for some time a younger brother, who was believed to play the violoncello divinely, and who certainly could apply himself with credit to mechanical pursuits. With untiring energy he worked out this ancient music of the spheres, till the world was astonished at his success, learning confessed her debts to his genius, and a new era dawned in the history of science. He sprang into fame almost at one bound, passed from theatre and music-room to the Hall of the Royal Society, and was saluted by organs of public opinion as an "extraordinary man."

Of the early life of this musician not much is known beyond the brief record by his sister and fellow-worker, Caroline Lucretia Herschel, written when she was past eighty years of age, and twenty years after his death. It was, as she styled it, "a little history of her own life, 1772–1778," not intended for the eyes of an admiring world, but prepared for her distinguished nephew, Sir John, the only son of her brother, Sir William Herschel. It is also a most interesting story of difficulties overcome in the pursuit of knowledge,—difficulties that were then almost insuperable,—of the devoted love with which she helped to smooth his path to fame, and of the moral beauty which ennobled her brother's life. An affection so touching between brother and sister is far from an uncommon thing in the records of mankind, but it never produced richer fruit or shone with brighter lustre than in the lives of William Herschel and his sister Caroline.

Frederick William Herschel,—although he dropped the name Frederick in England after 1758, till it reappeared in his son's name in 1792,—the fourth of a family of ten children, was born on November 15, 1738. His sister, Caroline Lucretia, the eighth of the family, was born on March 16, 1750. She was thus nearly twelve years his junior, an interval sufficient to surround the elder of the two with the haze of romance in the eyes of the younger. Between them there was a strong attachment, from the time the little sister could show or express her feelings. From infancy to old age he was "the best and dearest of brothers"; his son was her pet, her dearest nephew; and both were worthy of her affection. The dependence of a

weaker nature on a stronger was not the bond that united brother and sister in a lifelong devotion to science and to each other. There was something more noble. They were the two members of the family in whom genius and perseverance united to overcome difficulties. None of the others possessed equal genius; none of them were gifted with the same perseverance. What these two undertook they did with intense affection for each other, and with a determination not to be baffled, where others could not be blamed had they submitted to defeat. The other members of the family that enter into the story of the lives of these two were, the elder brother, Jacob, and the younger, Alexander; the one nearly four years older than William, and the other seven years younger. Flighty, vain, selfish, and uncertain, Jacob was a specimen of what the eldest brother in a family should not be, but is frequently allowed to become by indulgent and foolish parents. Of such inferior capacity to William that the latter mastered their French lessons in half the time taken by Jacob, he had the power of creating unhappiness by starting difficulties at everything that was done for him; by selfishly insisting on travelling comfortably by post, while his father, with an impaired constitution, and his brother William, a fast-growing and delicate lad, were content, for economy's sake, to trudge the weary miles homeward on foot; by whipping his little sister, sixteen years younger than himself, because, in her awkwardness, she did not come up to his lordly ideas of what a tablemaid should be to a man of his standing; by his bad humour when his beefsteak was hard, or because Caroline could not use brick-dust in cleaning the little

cutlery they possessed. There was no love lost between a brother of twenty, who could thus bully a sister of four or five, and make himself disagreeable all round. It would have been odd had he not sown in the girl's mind a plentiful crop of dislike or hatred. Alexander, so much nearer herself in age, was less disliked, but does not seem to have been, at first, much more loved. At one time it seemed as if he thought himself entitled to imitate the lordly ways of Jacob, and his contempt of the little sister, shy, small for her age, and uneducated even in the family inheritance, music. William, on the other hand, was a family idol to the girl and her parents. When she failed to find him and her father on the parade-ground after a year's absence from home, and returned to the house to see them all seated at table, "my dear brother William threw down his knife and fork, and ran to welcome, and crouched down to me, which made me forget all my grievances." The young soldier, the hero of her romance, was then eighteen years of age; the girl was six. Could a more charming picture of brotherly love have been drawn, or a firmer foundation laid for the sisterly affection that continued unimpaired through half a century of toilsome and absorbing work? With much difficulty the girl was allowed to receive some sewing lessons at a school where girls of higher rank were taught. It was the means of introducing her to a young lady who, as Mrs. Beckedorff, became a lifelong friend and companion at Windsor, and, sixty years later, at Hanover. Caroline was, as she says herself, the Cinderella of the family. "I could never find time," she wrote in 1838, "for improving myself in many things I knew,

and which, after all, proved of no use to me afterwards, except what little I knew of music, being just able to play the second violin of an overture or easy quartette, which my father took a pleasure in teaching me. *N.B.*—When my mother was not at home. Amen."[1]

The family, though poorly provided with worldly goods, was richly endowed with mental gifts, which had only to be well laid out to lead to wealth and fortune. The father, Isaac Herschel, came of a sturdy Protestant stock, which, about a century before his birth on January 14, 1707, escaped persecution in Moravia by emigrating to Saxony. Isaac's father was there employed in the Royal gardens at Dresden, and earned a name for himself as a skilful landscape gardener. A passionate love of music, however, compelled the son to forsake his father's business of gardening, and betake him to his favourite study under a hautboy player in the Royal band. After pursuing the study at Berlin and Potsdam, he journeyed in 1731 to Hanover, where he became a hautboy player in the band of the Elector's Guards, and where he married in the year following. George II. was then Elector of Hanover. To that connection with Britain was sometimes due our entanglement in the politics and wars of the Continent, and the bringing across of Hanoverian soldiers, perhaps of Hessians also, to defend this country when threatened with invasion by France. War brought its troubles to the Herschel family. From these troubles arose singular compensations for the advancement of science, the honour of the family, and the welfare of mankind. On the

[1] *Memoirs*, p. 299.

night after the battle of Dettingen (June 16, 1743) the bandmaster of the Guards, as the father had then become, lay in a wet furrow, which sowed in him the seeds of an illness that never left him during the rest of his life. It spread a cloud of gloom over the family circle for nearly twenty years.

Isaac Herschel was a man of intelligence, qualified to talk on higher matters than flute-playing or band music. But he was not head of his own house. Like many foolish fathers, he allowed the eldest son to usurp his place, nor did he shield the younger children from the eldest's bullying. Apparently the mother, a woman of small intelligence, had also a favourite in her eldest daughter, Sophia, who lived away from home, and whom Caroline did not see till she came back to be married to Griesbach, a musician of commonplace ability in the Guards' band. Sophia was then about twenty-one, Caroline four or five. Caroline liked neither her sister nor her sister's husband. But the married daughter did not remain long away from the family she left. War broke out, one of the interminable wars of Frederick the Great, which drove her back to her father's house. There the impatience of her temper and her dislike of children drove Caroline from little warmth or affection within the house to cold and neglect outside. What neither father nor mother would have allowed in a well-regulated family, the child was forced to endure, with sullen and natural resentment. An elder brother and an elder sister considered the position of household drudge good enough for Caroline, without schooling, and even without sewing. While the father and sons showed unusual knowledge, and even developed somewhat of genius

for music, this neglected girl was neither taught nor allowed to sing a note. Her anchor of safety lay in the simple devotion with which, even then, she worshipped "her best and dearest of brothers, William." She herself called it the affection of "a well-trained puppy-dog" for its master. In after life she showed more regard for her sister's son, George Griesbach, one of the musicians of George III.'s court, than she ever entertained for his father or mother. But her affection for him was lukewarm compared with the intensity of its glow towards another nephew, the son of her brother William, the distinguished mathematician and philosopher, Sir John F. Herschel. Of the latter she can never speak enough, nor in terms of praise sufficiently high: and deservedly.

Such was the household William Herschel was brought up in. It was, or might have been, a home of genius. The father had much in him of music and of knowledge generally to fit him for the training and encouragement of his sons. But they were not all equally worthy of his regard. Ill health, while they were still children, the eldest not more than ten, may have weakened his vital power at the time when it was most indispensable for him firmly to hold the household helm and keep every member in his own place. His wife was badly fitted to rule or guide their little community of boys and girls. She had to fight a battle with privation and a small income; she had to face the hostile occupation of the country, and the unscrupulous exactions of invaders. Driven from pillar to post, she pampered some of her sons, she petted a favoured daughter, and turned another daughter, more deserving of affection, into a household

slave. It was a poor home, badly governed, but rich in promise. She nearly wrecked everything by her folly; but that folly was strangely overruled for the welfare of humanity and the honour of her own children.

The *Memoirs* of Caroline Herschel furnish the only trustworthy account of the means, by which genius and hard work combined laid the foundation, on which her brother's fame was built. At the same time they have left room for myths or legends to supplement facts or to fill up gaps in the story of the first half of his life. This is unfortunate; but it was known to his sister, who was unwilling or unable to apply a remedy. It is thus not always easy to present the truth of these early years. So busy was she kept that in 1786 she writes, "For these last three years I have not had as many *hours* to look in the telescope."

CHAPTER II

THE EDUCATION

THE education of a child is commonly supposed to begin and end at school. It neither begins there nor ends there. Reading, writing, and arithmetic may, and should, be taught in every school, as the indispensable equipment of a boy or girl for the battle of life. But the real school is the world of life, however wide or however narrow its boundaries may be. Surroundings of one kind or another encompass child and man alike, forming the outer and larger school, in which all are entered as pupils for self-control, for truthfulness, for honour, and other often neglected but necessary virtues. In the elementary school for reading, writing, and arithmetic, Caroline Herschel can scarcely be said ever to have been entered. She was a neglected child in these respects. To a woman of her quickness of parts and calculating power the multiplication table continued to be a puzzle throughout life. Elementary learning was considered to be of little or no use to a girl who was to attend her brother's whims, cook his dinner, and brush his clothes. The mother, proud of her sons, took no thought of her little daughter, except to reckon up that the girl might save her a servant's wages. Other mothers have committed the same blunder since her

days with equally evil results. The ill health of the father, and their straitened means, may help to explain this neglect of the little girl, without excusing it. Up to the close of a long life she never ceased to regret and reprobate the treatment to which she was subjected in childhood. But, unlike her youngest brother, Dietrich, she laid no part of the blame for this neglect on their invalid father. "Dietrich," she says, "never recollected the eight years' care and attention he had received from his father, but for ever murmured at having received too scanty an education, though he had the same schooling we all of us had had before him."

It was different with her brother William. In Hanover there was at that time a garrison school, taught by a capable teacher. Master and pupil, finding in each other what the other wanted, were a credit to their fellowship in learning. All the children were in the habit of attending this school, from the age of two to fourteen; but Caroline seems to have got little good from it, and at two or even four years of age she would have been much better at home under a mother's care. The teacher had some knowledge of Latin and arithmetic. Out of school hours he imparted to William Herschel all he knew of these branches. French the boy also learned, as the polite language of the world of civilised men, and the tongue of the enemies of his King and country. English is not mentioned among his acquirements, although the Elector of Hanover was then George II. of England; but a King who spoke indifferent English at Windsor, or none at all, would not encourage the study of it in the garrison school at Hanover. Even the German

language did not then rank high in the estimation of kings and princelings who made a pretence to literature. It was the tongue of rude and ignorant boors. Among them French was the language of learning, literature, and politeness. William Herschel was too quick-witted to neglect the language of the country he was destined to look forward to for preferment. He became a proficient in English, though at the best it was sometimes dictionary English, with its long Latin words, that cropped up in his written pages. Towards the end of his life, his mother tongue, the rude language of Germany, as it was then deemed, became somewhat unfamiliar to him. His sister Caroline, after fifty years' residence in this country, had to consult an English dictionary to find or recover words sufficiently strong to describe the objects of her dislike. Her brother, after a longer residence in England, found difficulty in carrying on a conversation in German with the Chancellor of the University of Halle, who paid him a visit at Slough shortly before the close of his life: "All accounts from his native country seemed to please him, although the German language had become somewhat less familiar to his ear." So the visitor wrote. Both brother and sister appear to have felt as Caroline felt when she wrote in her eighty-sixth year that she was a countrywoman of the Duke of Cambridge and would not be a Hanoverian.

The schooldays of William Herschel ended at the age of fourteen; his real education then began. Under the careful instruction of his father, he had become an excellent performer on the oboe and violin. But the father had higher views for a young man of his

ability than to see him enrolled as an oboist in the band of George II.'s Hanover Guards. That was easy of attainment: it was merely the lowest round of the ladder, and did not lead to any height. The eldest brother, Jacob, became organist, at the age of nineteen, in the garrison chapel: he cannot be said to have risen higher. Even then the younger brother was cherishing wider, loftier flights for his ambition than would satisfy a father's eagerest wish in the way of musical success. What these flights were we can dimly see in a few glimpses of mental progress made by the young bandsman during the next few years.

The two brothers, it seems, were often introduced to take part as solo performers in concerts at the Electoral court. Keen criticism of the music followed on their return home. But the criticism was varied by philosophical and scientific talk, which frequently lasted all night. What was the cause of this unusual interlude in a musician's life we are not informed. But among the subjects of discussion were astronomy and mechanics, whether the taste for these studies was awakened or not by what they saw and heard at the court festivities. William Herschel himself showed a decided turn towards the invention and making of mechanical appliances, simple things it might be, but the first appearance above ground of what was destined to be a rich harvest. Encouraged by his father, he persevered in exercising his skill. Long years afterwards, the elements of mechanical skill which were thus fostered, developed into the works which enabled him to search the depths of space for its innumerable worlds.

Another subject which Isaac Herschel was not

ignorant of, and seems to have taught some of his children, was a knowledge of the starry heavens. Caroline, who enjoyed little of her infirm father's instruction and guidance, was sometimes taught by him to recognise stars and constellations in the cloudless nights; but the teaching then given was not seed that fell on a good soil. With William it was different. He was of an age and a disposition to be fascinated by the subject, and the golden hopes which the science at that time held out to astronomers must have coloured the dreams of many a youthful star-gazer. The British Government offered a great reward for the best means of finding the longitude of a ship's place at sea. A clockmaker might solve the problem by ingenious contrivances, and win the reward; or an astronomer, by more refined and more subtle methods, might furnish the sailor with knowledge and safety, and carry off the prize. William Herschel was a boy of thirteen when a young mathematician, almost self-taught, was appointed to a chair in the Hanoverian University of Göttingen, not forty miles from the town of Hanover.[1] It was John Tobias Mayer, who taught there from 1751 till his death in 1762, and whose widow got three thousand pounds of the reward for the solution he left behind him of the problem of the longitude. It is probable enough that the name of this famous astronomer, with whose writings Herschel became familiar in

[1] The favour with which Göttingen was regarded by George II., who founded both University and Observatory, could not fail to exercise an influence on Herschel and his father. In 1756 the King presented the Observatory with a mural quadrant of six feet radius, made by Bird of London.

after years, was of common occurrence in the talks of father and son. Nothing is more likely, for other great names are known to have been discussed between them. Another astronomer, afterwards a friend of Herschel, made himself a name in the scientific world, Schroeter, of the Observatory at Lilienthal, in the Duchy of Bremen, about twenty miles from Hanover. Olbers and Harding, two of the astronomers who afterwards undertook to rival Herschel in the discovery of planets, belonged to the same neighbourhood. There was at that time something in the air of Hanover and its neighbourhood that turned the eyes of young men of genius to the stars. It is therefore not surprising that students of the sciences so eminent as Newton, Leibnitz, and Euler entered freely into the talks between the father and his two eldest boys. Jacob preferred sleep to talk. William never grew tired of talk on men and subjects so attractive. He was surrounded by living and famous astronomers. Their works and fame served, probably, to nurse in him the spark of science that his father thus lighted or cherished.

The prospect of war with France in 1755 gave Herschel an opportunity of visiting the country of his dreams, England. Discontent was rife in our large towns; incapacity was still more rife in the army and navy. It was the age of Admiral Byng, of Lord George Sackville, and of the Duke of Cumberland. The French king was known to be planning, and was likely to carry into effect, a descent on the English coast. In April it was supposed the storm would burst on Ireland, for that island was so defenceless that ten thousand troops might walk from one end of it to the other. In October it was reported that a

flotilla of flat-bottomed boats was assembled at Dunkirk to transport an army to the English coast. The speculations of politicians were prefaced with, "If no French come." The situation was pronounced by some of them comical, and the nation droll. In March of the following year "the King notified the invasion to both Houses, and his having sent for Hessians. There were some dislikes expressed to the latter; but, in general, fear preponderated so much that the cry was for Hanoverians too." Hanoverian officers were even preferred to the native-born. But the cynics of London laughed, invented, and lied. "They said that the night the Hanover troops were voted, George II. sent for his German cook, and said, 'Get me a very good supper; get me all de varieties: I don't mind expense.'" Exquisites, like Walpole, were wondering where their foreign defenders would be encamped. If the Hanoverians should be stationed at Hounslow, "Strawberry Hill would become an inn, and all the misses would breakfast there, to go and see the camp!"[1] Even in George Townshend's "admirable" cartoon, "which so diverted the town," "the Hanoverian drummer, Ellis," "though the least like, was a leading feature." Instead of fighting, Englishmen were sneering or laughing.

It was in these days of fear and threatened invasion that the King's Hanoverian Guards were ordered to England.[2] Isaac Herschel and his two sons, Jacob and

[1] Walpole, *Letters*, iii. 109, 164, 165, 206, 209, 217.

[2] "Towards the end of the year 1755," Caroline Herschel says (p. 8). This does not seem to be correct. Horace Walpole's *Letters* would lead a reader to place it several months later, in 1756. Neither she nor her brother seems to have been sure of the date. (*Memoirs*, p. 218.)

William, were in the band of the regiment. Whether they encamped on Hounslow Heath and annoyed Strawberry Hill or not is unknown; but for a whole year they remained in England, till apparently the invasion of Hanover by the French rendered their presence necessary at home. There was no invasion of England except by a flute-player, who saw the comforts of the land, and came back a year later to make it and himself famous in the arts of peace, and to give Walpole a chance of handing down to posterity in his *Letters* the wonder excited, even among idlers and diners-out, by the earnest labours of William Herschel. The only spoil the musician carried home with him to Hanover was a copy of Locke's *Essay concerning Human Understanding*, on which he spent as much of his pay as he could spare. His brother Jacob took back some English goods and some fine clothes.

Caroline Herschel is of opinion that had it not been for the war troubles, in which Hanover was now involved, and had peace allowed these scenes of happy discussion between father and son to continue till their natural application to practice, her brother would have given proof of his inventive genius long before it revealed itself, in the thirty-sixth year of his age. Prophecies of this kind after the event are not uncommon, but they may be as groundless as they are uncertain. Seed was sown in Herschel's mind by an enlightened father, who "was a great admirer of astronomy, and had some knowledge of that science." The boy of sixteen was also encouraged by him to try his hand on mechanical contrivances, of which one took an especial hold on his sister's childish mind, "a neatly

turned 4-inch globe, upon which the equator and ecliptic were engraved." But it was from a passionate devotion to music that the father looked for fame and money for his two sons. He seems just to have missed that aim with the flighty Jacob;[1] it is pardonable to doubt that he could ever have attained it with the staid and persevering William. Neither of them had in him the making of a Handel, who was then, and had long been, the ornament of the English and Hanoverian court, and of whom the aspiring father could not fail to be always thinking.

A greater check to progress than war or poverty was the mother's dislike of learning. She was resolved that, in spite of her husband's wish to educate Caroline, nothing should be taught the girl but what might prove useful to her as a household drudge. She would not allow her to learn French; she relaxed so far as to send her for two or three months to a sewing school to be taught to make household linen, to which the girl added, out of her own ingenuity, the making of bags and sword-knots for her brothers' splendour at concerts, before she knew how to make caps and furbelows. The mother made no concealment of her reason for this unjust and narrow-minded treatment of her daughter. Referring to later troubles in which her own folly involved the family, she laid the blame where it had no right to lie: "It was her certain belief that William would have returned to his country, and Jacob would not have looked so high, if they had had a little less learning." "There is a great simplicity in the character of this nation," the physician of George IV. wrote of the

[1] Burney, *History of Music*, iv. 603. See *infra*, p. 32.

Hanoverians, when he accompanied that King on his visit to the Electorate in 1821. Perhaps Herschel's mother was an example of this great simplicity, misplaced. At least it resulted in years and recollections of exceeding bitterness to William Herschel and his sister. There can be little doubt that both of them laid on her the blame of great mistakes committed, and grave responsibilities incurred, which darkened her son's future life. Possibly it had something to do with the difficulty he had, as he approached his eightieth year, in drawing up an autobiography, as he wished to do. He found "himself much at a loss for the dates of the month, or even the year, when he first arrived in England with his brother Jacob." The work was handed over to Caroline, who undertook it with the "proviso not to criticise on my telling my story in my own way." Her youngest brother, Dietrich, the scapegrace of the family, was under three years of age when these sorrowful passages occurred in their household history. When past seventy he was as hard to deal with as in his teens. "Let me touch on what topic I would," she writes, "he maintained the contrary, which I soon saw was done merely because he would allow no one to know anything but himself." There were two strains in this large family, as there are in many others, one tending downwards, another soaring upwards, and the former is usually a grief to the latter. Jacob, Dietrich, and Sophia represented the one: William, Caroline, and, in a lesser degree, Alexander represented the other. The only one who made a fortune was William, and the one who got a larger share of it than any of the others, even than Caroline and Alexander,

who helped him to make it, was the scapegrace, Dietrich.[1] Family histories are strange things! And yet Caroline at seventy-eight years of age says to her nephew, "Whoever says *too much of me* says *too little of your father!* and can only cause me uneasiness," while Dietrich never believed he got even fair play for himself from parent, brother, or sister.

[1] See William Herschel's will, *Gentleman's Magazine*, vol. xcii. Dietrich got £2000, but Alexander and Caroline got £100 a year each. As things went in those days, the undeserving fared far better than the really deserving.

CHAPTER III

IN ENGLAND

FROM the brief and guarded indications given by his sister Caroline, then a child of seven, sitting on the outer doorstep and watching all that took place with the wondering eyes of childhood; from her picture of the mourning mother, and the parcel which she carried containing her son's accoutrements; from her view of the disguised brother stealing past, and from the prohibition even to mention his name, it is plain that William Herschel was smuggled out of Hanover in the summer of 1757. What we might call the conscription was then in full force in town and country to supply the beaten army of Cumberland with recruits. But Herschel was a soldier, and was running away from the colours. He was of a weakly constitution, growing rapidly, and unfit for the hardships of a soldier's life. So his mother said and, perhaps, also thought. For three months both Hanover and England had been expecting something to happen in the war with France. The Duke of Cumberland, of Culloden fame, found it necessary to go abroad to "take command of the army of observation." But so ill was he liked in England that, though "the drum was beat, none would list." The soldiers under his command in Hanover, and a motley crew

they seem to have been, appear to have viewed his ability as cynically as it was viewed in England. "We hear," Horace Walpole writes, "that the French have recalled their green troops, which had advanced for show, and have sent their oldest regiments against the Duke." Twelve days later, he says: "This is not the sole uneasiness at Kensington; they know the proximity of the French to the Duke, and think that by this time there may have been an action: the suspense is not pleasant." Five weeks later came the news, "We are in a piteous way! The French have passed the Weser, and a courier brought word yesterday that the Duke was marching towards them; and within five miles: by this time his fate is decided." A few days more, and tidings came that "the French attacked the Duke for three days together, and at last defeated him: I find it is called at Kensington an encounter of fourteen squadrons." It took place at Hastenbeck near Hameln, on the Weser, the scene of the Pied Piper's exploit. Whether an encounter or a battle, it was fatal to the reputation of the Duke, and the English officers he had with him; and it was fatal to Hanover, which from first to last paid more than two millions sterling to the victors. Above all, it was fatal to William Herschel's soldiering; for years also it was fatal to his prospects in life, and to his peace of mind as well as his sister's; but, at last, it was the beginning of his endless fame. We can almost sympathise with a deserter from such a general, especially when he fled to his own King for protection, not to the enemies of his country.

An anxious and far from sensible mother took steps to save her delicate son. The French were

about twenty miles to the south of the town; the roads were so bad that even a King's coach, sixty years later, drawn by eight horses, could not make a longer stage than five miles; an invading army would move more slowly. The north road towards the sea was clear of the enemy: and the German outposts extended no farther than the palace at Herrenhausen, about a mile and a half from the town. William Herschel passed these without molestation, journeyed along the Bremen road, and at last found his way to Hamburg, to which his trunk was sent after him. In the following year he appears to have crossed the sea to England. Obscurity then covers the fugitive's wanderings for nearly ten years. Five or six pages of sorrowful details are torn out of his sister's journal at this point; and the way of the wanderer is lost in darkness. More is told by her of the eldest brother's comings and goings, of his rude and ungenerous treatment of her, than of the brother whom she worshipped. We could have taken less of Jacob, and more of William,—"the best and dearest of brothers,"—as the circumstances manifestly required.

After the lapse of seventy years Caroline Herschel felt as keenly as she did at first the unpleasantness of her brother's flight from Hanover. On his return as a King's messenger in 1786, bearing a King's present to the University of Göttingen, the editor of the Göttingen *Magazine of Science and Literature* got from him some particulars of his early life, which it would have been better if he had not furnished. "In my fifteenth year," he wrote, "I enlisted in military service, only remaining in the army, however, until I reached my nineteenth year, when I resigned, and

went over to England."[1] Herschel's friends did not know how to gloss over this unhappy passage in his life. What they said in England was as wide of the reality as what he unfortunately said of himself—"Unable, however, long to endure the drudgery of such a situation, and conscious of superior proficiency in his art, he determined on quitting the regiment," and arrived in England in the end of 1757. This is not a barefaced statement of untruth, like the resignation of his position in the band.[2] But the mother's foolishness was singularly overruled for good.

Of William Herschel's wanderings after escaping from the beaten army of Cumberland the pages that are torn out of his sister's journal would probably have given information, but it is not till two years have passed that we again hear of him. He was then in England, along with his eldest brother, Jacob. On Jacob's return home in the end of 1759, William remained behind, studying apparently the theory of music. Many of his letters to Jacob on that subject were written in English, a proof apparently that his mind was made up not to seek his fortunes elsewhere. For five years he again almost disappears from view, till he is seen on a short visit to his Hanover home in the spring of 1764, to the joy of his family, especially of his father, then an invalid, and of his young sister, Caroline. In the interval his musical ability obtained for him in his adopted country the post of bandmaster to a regiment, stationed in one of the northern counties, said to have been the Durham Militia. The Earl of Darlington is said to have selected him "to super-

[1] Quoted in Holden's *Life and Works of William Herschel*, p. 4.
[2] *Gentleman's Magazine*, vol. xcii. (1822).

intend and instruct a military band then forming by that nobleman in the county of Durham. After this engagement ended, he spent several years in Leeds, Pontefract, Doncaster, etc." That he had been a soldier, officers and men would soon discover from his language and bearing. But he was, and seems to have remained, a mystery for years. In 1764 he was residing in Leeds, and went from that town on a visit to his relations in Hanover. Towards the end of 1765 he became organist of a church in Halifax, where he applied himself to the study of Latin, Italian, and mathematics. Music he continued to cultivate as his profession in life during these years of wilderness wandering.

Southey, in one of his stories from Doncaster,[1] represents Herschel, the astronomer, to have been, in 1760, "only a few months in England, and yet" able to speak "English as well as a native." Miller, the organist of Doncaster, who lived in a two-roomed cottage, but had a collection of classical English works, became acquainted with him through an officer of the Durham Militia, found that his engagement with that regiment was "only from month to month," and urged him to leave them, and take up his abode in the "but and a ben," which he did. Swift is alone mentioned as the English author Herschel preferred to read, which, though it be consistent with the list of favourite authors given by his sister, is not altogether satisfactory evidence of the authenticity of Southey's story. But, be that as it may, Miller was thus entitled to be called his "earliest acquaintance" in England, and certainly his best friend, if it be true that he en-

[1] *The Doctor*, ii. 251, from Miller's *Doncaster* (1804), p. 162.

couraged Herschel to apply for the organist's place in Halifax. But Miss Herschel in 1822 speaks of "Mr. Bulman from Leeds, the grandson of my brother's earliest acquaintance in this country,"[1] and tells us that in 1764 he paid them in Hanover a fortnight's visit from "Leeds in Yorkshire (where he must be left for some time)." The organist's place at Halifax does not date from 1760, but from 1765. The inconsistencies between Southey's story and Caroline Herschel's are too serious to allow us to accept his version of the means by which the organist's place at Halifax was gained in or about 1760 as true of "Herschel the astronomer." It is known that his brother Jacob was in England for two years about 1759.

While resident in Halifax, Herschel appears to have paid a visit to Italy, the ancient land of poetry and astronomy. Our authority for this is Niemeyer, Chancellor of the University of Halle, who visited Herschel at Slough shortly before his death, and seems to have received the details of the journey from his own lips. When he reached Genoa on his way home, he found himself short of money to meet expenses. He had gone to Italy to "improve himself in his profession of music"; and he put his improvement to use "by an original kind of concert he gave in that town, in which he played on the harp and on two horns fastened on his shoulders at the same time." He procured the money he needed, and, had he not been proud of his youthful success as a musician, would not have told the story, fifty years after, to his learned and distinguished visitor, as either he or his sister Caroline must have done. Her *Memoirs* contain no information on

[1] *Memoirs*, pp. 137, 326.

this tour and concert. Her brother William seems to have at that time fallen entirely out of her life, and to have left her, without education, to become a household drudge and the slave of her brother Jacob. But she cherished a spirit which, amid much that was extremely depressing, scorned to be the one or the other.

In the following year, 1766, William removed to Bath, where he became a teacher of music and organist of the Octagon Chapel. For five or six years after, obscurity again settles on his life and adventures. All that Caroline records is that Jacob joined his brother at Bath, and showed the same flightiness of disposition which the family had previously seen in his character. To speak of William as well known in the society for which Bath was then famous, or among the learned men and physicians by whom the town was frequented, is to people the darkness with visions of what we think should have been, but was not. He was little known there or elsewhere, till he took the world by storm; but at that period events were taking place in Bath which helped materially to lift the curtain of darkness off his life in 1772. He was then thirty-four years of age.

The musical director of Bath in those days was Linley, whose daughter Elizabeth, "at the age of twelve years, was brought forward publicly at the Rooms, where she so charmed the company by her taste and execution" as a singer, that she at once received the name of the Siren. Two years later she got a more attractive name, and was called the Angel. Her début took place in the very year Herschel came to Bath. Before she was seventeen she had turned the heads

of all the young men by her beauty and accomplishments. Offer after offer was made for her hand, but the preference was given by her father, for reasons not creditable to him, to a suitor very much older than she was, but immensely wealthy. With difficulty the girl was persuaded to agree to the match. She withdrew from all public engagements, and nothing was talked of in Bath but the approaching wedding. While the town was in this state of expectation, William Herschel, seeing that great prizes were in prospect for attractive singers, bethought himself of his sister Caroline, then two or three years older than Miss Linley. He proposed that she should join him at Bath, after receiving lessons from their eldest brother, Jacob, in the hope that she "might become a useful singer for his winter concerts and oratorios." Should the experiment not succeed, he promised to bring her back to Hanover at the end of two years. Evidently Jacob—he is described as "brilliant" — had been a failure in Bath. A bully, such as he was, could not help feeling that it was a reflection on him to suggest she might succeed where he had failed. Without ever hearing the girl sing, he "turned the whole scheme into ridicule," but she resented his conduct "by taking every opportunity when all were from home to imitate, with a gag between my teeth, the solo parts of concertos, *shake and all*, such as I had heard them play on the violin; in consequence I had gained a tolerable execution before I knew how to sing." The cruelty or stupidity of the eldest brother had no effect on William, except to deepen his determination to make this experiment.

Meanwhile, strange things were happening at Bath. Miss Linley's admirer threw up his engagement, and,

as compensation, paid her father a thousand pounds for the loss of her services at concerts. It was an eminently discreditable business all round. But the young lady did not want admirers, especially in a family which migrated to Bath in 1771. Two of its members were Richard Brinsley Sheridan and his elder brother, Charles, both of them as poor as their itinerant father, but as foolishly proud, though with better reason. The girl preferred Richard, and in that showed her good sense. But she was said to be so thorough a flirt, that she was at the same time giving Charles to understand he was the favoured suitor.[1] At last, knowing that her father's consent to a marriage with Richard would be refused, she eloped with him to France, and was placed by him in a convent. Brought back by her father, she was married to Sheridan on April 13, 1773. While this comedy was proceeding at Bath, Herschel made a brief run across to Hanover in April 1772, and returned for his sister in August. He was able to settle a small annuity on his mother in compensation for the loss Caroline's removal would entail on the household. She felt herself to be her mother's slave, to be bought and sold. After a journey of ten days, they reached London on the 26th of August, where, "when the shops were lighted up, they went to see all that was to be seen, of which she only remembered the opticians' shops, for she did not think they looked at any other."

[1] "Mrs. Sheridan is with us," Hannah More writes to her sister at Bristol in 1778, "and her husband comes down on evenings. I find I have mistaken this lady; she is unaffected and sensible; converses and reads extremely well, and writes prettily." Mrs. Sheridan was nine or ten years younger than Hannah More.

She came to England to be a public singer, she begins her work by a few lessons on optical instruments in the shop windows of London. Herschel had by that time evidently entered on the race for fame. His sister was twenty-two years of age.

Fourteen years after, when she had become a celebrity in all the observatories of Europe, at the Royal Society, and in the palace at Windsor, she is thus described by a young woman, who was then as famous for her pen as Caroline became for her comet-finder. "She is very little," the authoress of *Evelina* writes, "very gentle, very modest, and very ingenuous; and her manners are those of a person unhackneyed and unawed by the world, yet desirous to meet and to return its smiles. I love not the philosophy that braves it. This brother and sister seem gratified with its favour, at the same time that their own pursuit is all-sufficient to them without it." "I inquired of Miss Herschel if she was still comet-hunting, or content now with the moon? The brother answered that he had the charge of the moon, but he left to his sister to sweep the heavens for comets."[1] Was this famous little lady above thinking of the small things which delight the fancy of less remarkable women? In her case, would the answer to the prophet's question, Can a maid forget her ornaments, or a bride her attire? have been *Yes*! Far from it. When she made her first public appearance as a singer "her brother presented her with ten guineas for her dress," and she tells us herself that her "choice could not have been a bad one," as the proprietor of the Bath theatre pronounced her "to be an ornament to the stage!" All

[1] (Fanny Burney) Madame D'Arblay, *Letters*, etc., iii. 442.

the same, intercourse with fashionable young ladies in London did not give her a high opinion of them or their attainments, "she thought them very little better than idiots."

About three years after his daughter's marriage, Linley withdrew from Bath. His place was supplied by William Herschel, who, to quote Niemeyer's words, "led the band at the theatre, conducted oratorios, and instructed some able pupils in that city." At that time "the Bath orchestra and its pump-room performances were the theme of general commendation in England," and to maintain the same standard of excellence, especially after the Misses Linley's retirement, entailed heavy and unremitting labour on the new director. Whether Herschel entertained the idea or not that he might succeed with his sister Caroline as Linley had succeeded with his two daughters may be open to doubt, but it is unquestionable that he had it in his power to make the trial, and that he did bring her out as a public singer. The gains of success were large and tempting. Miss Linley, now Mrs. Sheridan, was offered a seven years' engagement in London at a thousand a year for twelve nights' singing, and as much more for a benefit. Success held out such dazzling prospects, that the certainty of failure could alone have prevented Herschel from persevering in his attempt to train his sister as a professional singer. And he did not persevere. The lot of Caroline Herschel was not destined to be that of a public singer; it was to be the lot of a woman of science at a time when few of her sex could aspire to that honourable rank. Had William Herschel succeeded in turning out his sister as a public singer, or in placing her on the throne vacated by Miss Linley, would his race for

bread not have become a race for riches instead of a race for fame? She herself had hopes of becoming a *prima donna* in the music world. Her friends cherished the same hope. But neither for her nor for her brother William did the race for fame lead along that road. For her brother Jacob, her detestation, it might possibly have so led. Dr. Burney, the author of a *General History of Music* and other works, was also of that opinion. William Herschel to him was the "greatest astronomer" of the age, while of Jacob he writes: "Herschel, master of the King's band at Hanover, and brother of the great astronomer, is an excellent instrumental composer in a more serious and simple style than the present."[1] Other women are mentioned by Dr. Burney among the singers of fame in those days, but Miss Herschel gets no such honourable mention in the annals of music.

For some years following her arrival in England the lives of the two Herschels are so intermingled that the history of Caroline is to a large extent the history of William also. They were both running the same course, and the one was holding out a helping hand to the other in the same race, the race for bread and the race for fame. Flighty, uncertain, bullying Jacob sunk out of their life in October 1787; but another brother, more to Caroline's mind, had entered it, and continued to diffuse a pleasant savour in the household at Bath, Alexander,[2] about five years older than his sister. He was of great assistance both as a violinist and a mechanician. Alexander was not of the same cheery, hopeful nature as William. On the contrary, he went amongst

[1] *History*, iv. 603.

[2] Born November 13, 1745.

them by the name of Dick Doleful, and when he fell into the dismals, as he seems frequently to have done, William and Caroline had the pleasure of laughing him out of them into good humour. The house[1] was managed by the family of Mr. Bulman, William Herschel's "earliest acquaintance in this country," with whom he lodged in Leeds, and for whom he procured the situation of clerk to the Octagon Chapel. They occupied the parlour floor. "Alexander, who had been some time in England, boarded and lodged with his elder brother, and with myself," Caroline says, "occupied the attic. The first floor, which was furnished in the newest and most handsome style, my brother kept for himself. The front room, containing the harpsichord, was always in order to receive his musical friends and scholars at little private concerts or rehearsals." A household so constituted, with a manager in charge "who had failed in business" in Leeds, and a strong-minded young woman who had known the thrift and drudgery of a poor German home in Hanover, had not in it the elements of stability. In six weeks, apparently, Caroline had to take the reins of household management into her own hands. No details are given; but, while still unable to speak English with comfort to herself, she was put in charge of the house accounts, and attended to the marketing, with her brother Alexander on guard behind to see that she found her way to market and home again in safety. The first time she ventured into a clamorous crowd of sellers, she brought back whatever in her fright she could pick up. But her battles with servants and her horror of waste were

[1] No. 7 New King Street.

greater trials to temper than buying from market-people. These were troubles which worried her through life, though a reader may smile at the recital of Cinderella's sufferings. Of the poverty in her childhood's Hanover home, she wrote when she was seventy-seven years of age, and had gone "back again to the place where," she says, "I first drew breath, and where the first twenty-two years of my life (from my eighth year on) had been sacrificed to the service of my family under the utmost self-privation without the least prospect or hope of future reward." Even then her trouble with servants never left her: "I may perhaps be spared a long confinement before I leave this world, else such a thing as a trusty servant is, I believe, hardly to be met with in this city of Hanover, which, along with the people in it, are so altered since the French occupation and the return of the military with their extravagant and dissipated notions, imbibed when in Spain and England, with their great pensions, which they draw from the latter country, that it is quite a new world, peopled with new beings, to what I left it in 1772."

This young housekeeper and singer found herself in a world of astronomical talk, for which she had no liking, when she left her humble home in Hanover with her brother William. For six days and nights they travelled in the open and inconvenient *postwagen* of those times to the seacoast at Hellevoetsluis, where they were to take ship for England. So clear were the nights that William pointed out to his sister the stars and constellations of the northern sky. Arrived at Bath, she was launched on the study of music and the practice of singing, but during the long nights of

winter William, evidently to divert her mind from the depressing home-sickness which weighed it down, gave her lessons in astronomy, or amused her with dreams that in a few years became waking realities. He was running a hard race for daily bread, for the thirty-five or thirty-eight lessons a week which he gave to music pupils might be counted work enough for an ordinary man, without reference to his duties as organist and manager of concerts. But he had also entered the arena of science in the race for lasting fame. A holiday from teaching meant for him increased work in the astronomical studies which were now absorbing his time and thoughts. "It soon appeared," his sister writes, "that he was not contented with knowing what former observers had seen, for he began to contrive a telescope eighteen or twenty feet long (I believe after Huyghens' description)." Her help was continually wanted in executing the various contrivances required. Although the lenses were ordered from London, she had to make the pasteboard tube they were fitted into, and when the telescope was turned on Jupiter or Saturn, she had to keep the paper tube straight till her brother got a peep through it. We need not be surprised to read her complaint that her music lessons were much hindered by astronomy, housekeeping, and indifferent servants. She was realising an old truth. Her brother and she imagined that service to two or three or even to four masters was possible. They were finding out that they could really serve only one. And slowly but surely William Herschel and his sister were drifting into the service of the one master, not the fleeting fame of a singer but the lasting fame of a discoverer. But those days of singing were never

forgotten. In the last year of her life, when visited by the Crown Prince of Hanover, his wife and child, she sang to them a composition of her brother William's, "Suppose we sing a Catch." The gulf between 1780 and 1847 was at once beautifully bridged by the little old lady of ninety-seven!

Dollond had shown in the *Philosophical Transactions* for 1758 how the colours, that rendered a refracting telescope useless as a means of discovery, might be obviated. He pointed out to his countrymen how flint glass and crown glass corrected each other's defect, and might be used, as they had never been used before, to search into the depths of heaven. It was a marvellous discovery; but thought in those days was perhaps slower of action than it is now, for a seed of truth, laden with immense possibilities, lay dying in the ground for sixty years, till Fraunhofer of Munich applied it to construct the great refractor of Dorpat. But it was reflecting telescopes of the Newtonian and Gregorian pattern, not refractors such as Dollond's, to which the enthusiast of Bath finally turned his attention. What Gregory and Newton had proposed or executed on a small scale, Herschel proceeded to build with his own hands on a vastly larger, after finding that the cost of even a small telescope would be above the price he "considered it proper to give." It was not a case, as might be supposed, of the narrow insularity of our countrymen thus to neglect a great discovery by following out a more cumbersome English method. Gregory, Newton, Dollond all belonged to this country. It was also the adopted home of Herschel, but he preferred the toilsome telescopes of the two former to the simpler and now possible instrument of the latter.

"At Bath in my leisure hours," he says, "by way of amusement, I made for myself several 2-feet, 5-feet, 7-feet, 10-feet, and 20-feet Newtonian telescopes; besides others of the Gregorian form of 8 inches, 12 inches, 18 inches, 2 feet, 3 feet, 5 feet, and 10 feet focal length. My way was . . . to have many mirrors of each sort cast; and to finish them all as well as I could; then to select by trial the best of them, which I preserved; the rest were put by to be repolished. In this manner I made not less than 200, 7-feet; 150, 10-feet; and about 80, 20-feet mirrors, not to mention those of the Gregorian form, or of the construction of Dr. Smith's reflecting microscope, of which I also made a great number. . . . The number of stands I invented for these telescopes it would not be easy to assign."[1] The story he tells of this magnificent "amusement," if less racy than his sister's, is far more wonderful. Could these mirrors have been sold at the prices then ruling the market, a large fortune would have rewarded the maker, as it ultimately did.

In June 1773 the new departure of Herschel commenced. Some of his pupils had left Bath; concerts, oratorios, and the theatre were at an end for five or six months. "To my sorrow," his sister writes, "I saw almost every room turned into a workshop." A cabinetmaker was making a tube and stands of all kinds in the drawing-room; her brother Alexander was "turning patterns, grinding glasses, and turning eye-pieces" in a bedroom; and while this manufactory was in its busiest whirl, William Herschel was besides composing glees, catches, anthems for winter consumption in the public rooms and the chapel, or holding

[1] *Phil. Trans.*, 1795, pp. 347–48.

rehearsals frequently at home. Alexander had to leave his turning-lathe for these rehearsals, and the seldom enthusiastic sister writes of him, "his solos on the violoncello were divine." It was work without intermission. Even at meal-times William was generally employed "contriving or making drawings of whatever came in his mind." Tea and supper were served without interrupting the work he had on hand. While he was at the turning-lathe or polishing mirrors for telescopes, Caroline read to him *Don Quixote*, the *Arabian Nights*, a novel of Sterne or Fielding. In course of time she became as useful a member of the household as a boy might be to his master in the first year of his apprenticeship. Still more "to drill me for a gentlewoman (God knows how she succeeded) two lessons per week for a whole twelvemonth from Miss Fleming, the celebrated dancing-mistress," were deemed indispensable. The drollery of the thing! "As I was to take part the next year in the oratorios!" nothing is wanting to complete the fun but "two lessons per week" at so much a lesson! The old lady who wrote this story of work and drollery—both of them perhaps detested by her when she was still a fraulein fresh from her poor Hanover home—may have laid the colours a little too thickly on the picture of work, earnest, all-absorbing work, and absurd fun, which she left to posterity. We may well be gratified she has, for if she escaped from the sneers of bullying Jacob, she certainly fell into the hands of exacting William. The difference was that she detested the former, worshipped the latter, and made a great name for herself as well as helped to make a greater for him.

She entertained the idea that her power as a singer

would have assured her a respectable, if not a handsome income, had her voice been cultivated, as it was not. Others of the family, reading her *Memoirs*, appear to have shared her sentiments. It is very doubtful. Her brother William—"best and dearest of brothers"—must have thought otherwise, when he allowed her music lessons to be hindered by marketing, incompetent servants, and other trifles.

The story told by Herschel himself of his struggles in Bath and afterwards, if less racy, is certainly more wonderful. Encouragement he seems to have had from no one, not even from Caroline, who submitted, not without grumbling, to his whims or caprice.

He was pursuing his studies with a devotion which, to one who reads the papers he afterwards wrote, calls to mind the devotion of the patriarch in pursuit of his mistress's love. "In the day the drought consumed me, and the frost by night; and my sleep departed from mine eyes." Most literally true was this as a picture of the astronomer's labours at Bath. "The tube of my seven-feet telescope is covered with ice" is his journal entry one autumn night. A month later he writes, "It freezes very hard, and the stars are very tremulous." Two months later, in midwinter, we read, "Not only my breath freezes upon the side of the tube, but more than once have I found my feet fastened to the ground, when I have looked long at the same star." On removing to Windsor, there was no falling away in his devotion to this imperious mistress. "At four o'clock in the morning," he writes on New Year's Day 1783, "my ink was frozen in the room; and, about five o'clock, a twenty-feet speculum, in the tube, went off with a

crack, and broke into two pieces. On looking at Fahrenheit's thermometer, I found it to stand at 11°." And, in the height of summer that year, "the telescope ran with water all the night," that is, "the condensing moisture on the tube has been running down in streams." "The small speculum, which sometimes gathers moisture, was never affected in the 7-feet tube, but was a little so in the 20-feet. The large eye-glasses and object-glasses of the finders required wiping very often." Such were some of the discomforts cheerfully undergone by this votary of science in pursuit of truth.[1]

Amid labours so continuous and so heavy it cannot occasion surprise that Caroline sometimes found relief in a fit of grumbling. When her brother was polishing a mirror, "by way of keeping him alive, she was constantly obliged to feed him by putting the victuals by bits into his mouth. This was once the case when, in order to finish a seven-foot mirror, he had not taken his hands from it for sixteen hours together."[2] The delicate lad, who, by his mother's address, escaped soldiering in 1757, had grown into a powerful athlete in 1772. This sometimes happens. Four years later he tried to improve on Newton's telescope by almost doubling the light let fall on the mirror at the bottom of the tube. He then experimented with a ten-feet reflector, but failed. He repeated the attempt with a twenty-feet in 1784, but again was disappointed: "it was too hastily laid aside." He succeeded shortly after, and found "it to be a very convenient and pleasant as well as useful way of observing": it inverts the north

[1] *Phil. Trans.*, 1803, pp. 215–19.

[2] Lalande told the same story in 1783. See Arago.

and south, but not the preceding and following."[1] He called it the Front-view, meaning that he tilted the mirror a little at the bottom, and, dispensing with Newton's plane mirror at the object end, secured all the light he could.

At that epoch in the world's history there was a singular upheaval of human thought and effort. In the years between 1760 and 1785 the world may be said to have witnessed more surprising changes than any it experienced since the revival of letters and the discovery of America. James Cook, aided by Joseph Banks and other men like himself, discovered new lands or new worlds of great extent and beauty in the bosom of the ocean; William Herschel, as the famous astronomer Lalande expressed it, "displayed a new heaven to earth," and discovered seventy-five millions of sunny stars. James Watt had solved the problem of converting the unruly giant of Steam into an obedient slave of man—the beginning of endless improvements in the bettering of man's lot. Gibbon had begun his *Decline and Fall*, Robertson was writing his Histories, and Hume was stirring the whole world of thought by the boldness and novelty of his ideas. Even in the political sphere that period was a seedtime fruitful of changes. The new world had changed hands. The Anglo-Saxon race and language had triumphed; the future of North America at least was assured. So was the future of India to the same hardy stock. Voltaire and his fellow-workers were paving the way for the violent upheaval that soon came in Europe. Everywhere men were sowing the seeds of a harvest of progress and blessing, mixed and disfigured with many a root of

[1] *Phil. Trans.* for 1786, p. 499.

bitterness. But among the purest and freest from vice of all the harvests reaped from the seedbed then tilled and sown, was that of William Herschel in his laborious study of the stars. It left no bitter weed behind it to poison or deface the riches of its harvest.

Herschel was prospering in worldly circumstances amid this stress of effort and thought. He had learned also what a great poet expressed in words some years after: "The excellence of every art is its intensity, capable of making all disagreeables evaporate, from their being in relation with beauty and truth."[1] His intensity required more room for its exercise. He was realising, he was putting into practical form Laplace's idea of a philosopher as one "who, uniting to a fertile imagination a rigid severity in investigation and observation, is at once tormented by the desire of ascertaining the cause of the phenomena, and by the fear of deceiving himself in that which he assigns."[2] Accordingly, he first "moved to a larger house, which had a garden behind it, and open space down to the river." It should be a place of pilgrimage to astronomers, for there discoveries were made, and also what were thought to be famous discoveries, but were not, and there the mirror for a great telescope was finished. Alone, without encouragement from the outside world of science, plunged in the depths of triflers' gay idleness, and sometimes subjected to the sharp tongue of his sister Caroline, this unwearied worker toiled on to his goal. He was determined to see what others had not seen, to know what others had not discovered. And he succeeded in reaching that goal.

[1] Keats, *Life*, i. 92.
[2] *System of the World*, ii. 310.

When his sister expected him to cheer her lonely life by lesson or talk, he was so absorbed in work that he withdrew to his bedroom to study some favourite author, and fell asleep in the midst of his books. One of the favourite works she mentions was the *Astronomy* of James Ferguson, published in 1756, the work of a self-taught Scottish peasant, whose proudest boast, had he lived to see the result, would have been that he did as much as any man, perhaps more, to start William Herschel on the path which led to results undreamed of in the history of science. And the book that Herschel thus fell asleep over was published anew by a famous man of science after Herschel's death, and was enriched with the multitudinous observations of the great astronomer. Master and pupil were embalmed together in that edition of the *Astronomy*, which can still bear comparison with any books of the kind that have been published, without coming out second best.

But the time of revealing William Herschel to the world as a practical astronomer of the first rank was now at hand. That he was little known in Bath and its neighbourhood we might gather from the silence observed regarding him by Hannah More, whose sisters kept a girls' school in Bristol, where she also resided. She was a lover of astronomy, and in 1762 made the "acquaintance of Ferguson, the popular astronomer, then engaged at Bristol in giving public lectures—an acquaintance which soon ripened into friendship."[1] But the girl who, as a woman of thirty-four, knew and recorded her impressions of Miss Linley, finds no place in either her Bristol or her London gossip for the far greater name of William Herschel, who conducted

[1] *Life*, etc., i. 16.

oratorios even at Bristol, was a favourite at Court, and was famous throughout Europe. Truly it may be said to Herschel what the passing traveller said to Archytas,

> "Nec quidquam tibi prodest
> Aërias tentasse domos animoque rotundum
> Percurrisse polum morituro."

Still, there can be no doubt that his discoveries became the talk of London and the world. Perhaps, also, many a British patriot, in indignant condemnation of the folly and tyranny which alienated the United States of America from the parent stock, was echoing the words of Horace Walpole, "Mr. Herschel will content me if he can discover thirteen provinces," among his twenty millions of worlds, "well inhabited by men and women, and protected by the law of nations, and can annex them to the crown of Great Britain, in lieu of those it has lost beyond the Atlantic."[1]

[1] *Letters*, vi. 258. On Herschel's life in England, and especially in Bath, see Appendix.

CHAPTER IV

THE DISCOVERY OF HERSCHEL

HERSCHEL had been studying the stars with improved telescopes for upwards of four years before any of the literary and high-placed people, who flocked every winter to Bath, knew that a man of genius lived among them and was a servant to their gaiety or devotion. Beau Nash had been a better known figure in their streets, a more respected man among a community of fops, idlers, and intriguers, and was deemed more worthy of a statue in their pump-room or their public park.[1] The man among them, who was destined to write his name on the heavens and to live when triflers and fops were all forgotten, attended their church meetings as an organist, their concerts as a conductor, and their drawing-rooms as a teacher of music to them or their children. They had not discovered that, by the irony of fate, a genius, head and shoulders above them all, was toiling for bread one half of the year, and slaving for fame or the welfare of mankind for the other half. He was really running two races before their eyes at the same time, the

[1] "At the east end of the saloon, a posthumous marble statue of the *great* Nash, executed by Prince Hoare, at the expense of the corporation, is handsomely ensconced" (Granville (in 1839), *Spas of England*, ii. 394).

indispensable race for bread along one course, which they all saw and had little or no sympathy with, and the unquenchable race for fame along another totally unlike, to which they were altogether indifferent. To run both races at the same time required a spirit of indomitable energy and perseverance.

In the world of literature and science it is not unfrequently the hard fate of genius to be passed by in the crowd, till some onlooker discovers it, as a diamond may be discovered among a heap of common stones on the roadside. The fire of genuine inspiration may have warmed the heart or lighted up the eye; but, until the onlooker, long waited for, it may be, goes past, no difference will be seen between a genius and other men by the ordinary crowd of humanity.

Ministers of state, heads of political parties, busybodies filled with national affairs were seen, recognised, or pointed out in carriages or places of public resort by those who enjoyed or were compelled by doctors' orders to endure the weariness of the place.[1] But "there are forty thousand others that I neither know nor intend to know," Walpole wrote: "in short, it is living in a fair, and I am heartily sick of it already." In the very year in which these words were written, Herschel was settled at Bath. He was one of the forty thousand nobodies, but Walpole was compelled in good time to reckon him a power in the world; he was only a poor player in the world's fair at Bath.

Court ladies and people of distinction knew William Herschel at Bath. They patronised him and his sister,

[1] See Walpole's *Letters from Bath*, v. 160, Oct. 2, 1766.

got him pupils, and did what they could for him in the race for bread. But they had no idea that he was at the same time running a race for fame, or, to speak more correctly, was preparing to step into that arena. They would have smiled an incredulous smile had anyone said so to them. A music master and a director of concerts they could understand and appreciate as an inferior creature; but a man who pottered about reflectors and refractors, and looked at the moon from a back garden or a street, when the rest of the world had gone to bed, was beyond their comprehension, or probably came in for their pity. And yet it was on a street, and late at night, that the genius of Herschel was discovered by an inhabitant of Bath, a perfect stranger to him and his scientific pursuits. So curious is the romance of the discovery that it is best told in Herschel's own words.

"About the latter end of this month [December 1779] I happened to be engaged in a series of observations on the lunar mountains, and the moon being in front of my house, late in the evening I brought my seven-feet reflector into the street, and directed it to the object of my observations. Whilst I was looking into the telescope, a gentleman coming by the place where I was stationed, stopped to look at the instrument. When I took my eye off the telescope, he very politely asked if he might be permitted to look in, and this being immediately conceded, he expressed great satisfaction at the view. Next morning the gentleman, who proved to be Dr. Watson, jun. (now Sir William), called at my house to thank me for my civility in showing him the moon, and told me that there was a Literary Society then forming at Bath,

and invited me to become a member of it, to which I readily consented." The house in front of which this discovery of an astronomer was made, was in River Street,[1] and the discoverer of Herschel was Dr. Watson, a distinguished Fellow of the Royal Society of London,[2] and a man of whom Herschel afterwards spoke in his printed papers with the highest respect and gratitude.

A look through a telescope in a street-observatory was not uncommon then even for a rising philosopher. As Humphry Davy "was passing through the streets one fine night, he observed a man showing the moon through a telescope. He stopped to look at the earth's satellite, and tendered a penny to the exhibitor. But the latter, on learning that his customer was no less a person than the great Davy, exclaimed with an important air, that 'he could not think of taking money from a brother-philosopher.'"

Dr. Watson and his father, Sir William Watson, were well-known members of the Royal Society. To the father in 1745 was awarded the Copley Medal for "surprising discoveries in electricity, exhibited in his late experiments." His portrait also is one of those in the Royal Society's keeping. The son became a Fellow in 1770. Like his father, he had a leaning towards the study of electricity. In 1756, when the Society honoured itself by electing Benjamin Franklin, "although not an inhabitant of this island," a Fellow, the certificate recommending that this be done was signed by the President and

[1] He soon afterwards removed to 19 New King Street.

[2] Dr. Watson seems to have done a similar kindness to others. See *Annual Register* for 1783 [58–60].

seven others, of whom W. Watson, the father, was one. In 1762, Dr. Watson in a letter to the First Lord of the Admiralty[1] recommended that the navy should be supplied with lightning-conductors of a pattern he devised. The ships were furnished with them, but they were not a success, and sixty years elapsed before conductors of a suitable construction were fastened to the masts. Long before then the danger of powder magazines on land from lightning had been recognised and provided for, but not without something like civil war among the Fellows of the Royal Society. A committee, of which Franklin and Dr. Watson were members, reported strongly in favour of *pointed conductors* for the powder magazines at Purfleet. One member not only dissented, but formed a party, who wrote and acted in favour of *blunt* and against *pointed* conductors. Again a committee was appointed, of which Dr. Watson was a member, to put the matter to the test of experiment. Their conclusion was the same as before. Unfortunately, this was in 1777, at the height of the war with the American colonies. Party politics were at once dragged in to decide a purely scientific question. Franklin was in favour of the lightning-rods ending in *points*. Philadelphia also had been provided with them, and "not a single instance" of mischief from the severe thunderstorms experienced in that city had happened. That was enough with foolish people to condemn *points* and favour *blunts*. The Royal Society decided for *points*; all who voted on that side were counted friends of the American rebels, as the phrase then went. King George III. took the side

[1] Lord Anson (*Phil. Trans.*, Dec. 16, 1762).

of the *blunts*. When Franklin was informed of the King's action, he wrote from France: "The King's changing his *pointed* conductors for *blunt* ones is a matter of small importance to me. . . . For it is only since he thought himself and family safe from the thunder of Heaven that he dared to use his own thunder in destroying his own subjects." But George III. went further. He even endeavoured to make the Royal Society rescind their decision in favour of *points*. Sir John Pringle, the President,—a man who had been Professor of Moral Philosophy in Edinburgh, who was physician-extraordinary to the King and Queen, *vir illustris de omnibus bonis artibus bene meritus*,—when urged to use his influence against *points* and for *blunts*, manfully replied, "Sire, I cannot reverse the laws and operations of nature." A late[1] addition to the story is that the King replied, "Perhaps, Sir John, you had better resign." That he did resign and withdraw to Edinburgh a year afterward, is certain: whether *points* and *blunts* had any influence in causing him to take that step is uncertain, but it can scarcely be doubted that the King's interference in a scientific quarrel had something to do with the censure passed on his generosity by Dr. Watson, the son, four years afterwards.[2]

[1] In 1820.

[2] Sir John, after his return from Edinburgh to London in 1781, had the pleasure of spending a couple of hours on week-nights at a society of which he had been for many years a member, and where he met "with such friends as Mr. Cavendish, Dr. Heberden, and Dr. Watson." It was at one of these meetings that Sir John, on the 14th of January 1782, was seized with a fit from which he never recovered. In August of that year, with his friend's death still fresh in his thoughts, Dr. Watson gave expression to his sentiments regarding the King's shabbiness (*Annual Register*, 1783 [45]).

Possibly, Dr. Watson shared the opinion of Franklin's friend, who wrote the epigram—

> "While you, great George, for knowledge hunt,
> And sharp conductors change for blunt,
> The nation's out of joint:
> Franklin a wiser course pursues,
> And all your thunder useless views
> By keeping to the point."[1]

Dr. Watson's discovery soon bore fruit. Herschel had been carefully studying the planet Saturn since the spring of 1774. He had also been observing the mountains on the moon's face and making calculations of their height. Besides, he had been watching a variable star in the neck of the constellation called The Whale. Four months after his introduction to Dr. Watson, he communicated to the Royal Society through him two papers, which were read on May 11, 1780, and modestly described as by Mr. William Herschel of Bath. The first of the two was "On the Periodical Star *in Collo Ceti*." The paper in itself was not of much consequence, and it was on an old and well-worn subject;[2] but it showed the books which had influenced him in his astronomical studies, as his sister had found by experience, and the carefulness with which he had for years been making observations on the stars. He had no desire to be considered an amateur. He was in thorough earnest, keeping a journal of what he saw in the skies, and carefully noting every change for future reference. On this Stella Mira, or Wonderful Star, as it was called from the "surprising appearances" it was known to present,

[1] Weld, *Hist. of the Royal Society*, ii. 7, 94–101, 392.
[2] See Lalande, i. 314 (edition 1771).

and the changes it was found to undergo in 333 or 334 days, he made at least fourteen separate observations and measurements between October 20, 1777, and February 7, 1780. He was only feeling his way as a recorder of what he saw in the heavens. It was but a beginning, and he was forty-two years of age.

To do justice to this eager lover of nature, the object which he had in view when he began to make telescopes for himself, should not be forgotten. He wanted to see with his own eyes what others had seen in the heavens, he hoped to see more than they had seen, and at last he determined to build an instrument of such power as should penetrate the depths of space far beyond the boundaries man had at that time attained. His purpose was to see the heavens as the telescope had revealed them to the eyes of others; it was not to be an assistant in an observatory such as Greenwich, content to discharge the routine work of each day, or perhaps of each night. A telescope, a most powerful telescope, was the purpose deeply rooted in his mind; it was not to improve the instruments then in use, nor to systematise the work done in observatories. Perhaps he had a large share in doing both. He read the scientific world a lesson on the necessity of all-night as well as all-day work, which they stood much in need of learning. Great and valuable as was the work done at Greenwich then and previously, it was done at small expense to the nation. An astronomer-royal at £300 a year, an assistant at £70, and a kitchen-garden was the kailyard policy pursued by our country up to 1811. Remonstrances were presented

to the Government of the day. The salary was then doubled, "thirty chaldrons of coals and one hundred pounds of wax candles" were asked for, and the enclosing of the kitchen-garden! Evidently the official mind had not grasped the idea that the astronomer-royal was no longer a fortune-telling interpreter of the heavens, as Kepler had been forced to become for bread! With one assistant all-night work was barely possible![1] The instruments in use may be judged of from "An Account of the Equatorial Instrument," or "mural quadrant," given to the Royal Society in 1793, twenty years after Herschel began his labours. The precision of observation among the ancients could not be trusted to within from five to ten minutes. Tycho Brahe reduced the probable limit of error to within one minute. Hevelius in the following century brought it down to fifteen or twenty seconds, and in the century after it was reduced to seven or eight seconds.[2] To entitle observations to any credit it was then felt that a probable error of more than a few seconds could not be admitted—or perhaps only a hundredth part of the errors unavoidable in the days of Hipparchus. In 1827, Sir John Herschel was able to say that he had "secured such a degree of precision that the stars cross the wire often on the very beat of the chronometer when they are expected." Clocks, transit-instruments, mural-circles may be said to have been in their infancy when Herschel began his work. He did not propose to work or measure with these as men do in an observatory. He was eager to see with a telescope; but he soon found that, if he was to do any good, he would require to

[1] Weld, ii. 250.

[2] *Phil. Trans.* for 1793.

observe and measure as well. He was one of a race of working astronomers of whom England had cause to be proud. They might be called, but they were not amateurs.

The second paper, read the same day, and headed "Astronomical Observations relating to the Mountains of the Moon," was more ambitious, and formed a better prelude to the path of discovery, on which Herschel would soon enter. He begins with an apology for attempting to ascertain the height of the lunar mountains, but a "knowledge of the construction of the moon leads us insensibly to several consequences, which might not appear at first; such as the great probability, not to say almost absolute certainty, of her being inhabited." He is equally certain that the moon rejoices in an atmosphere like the earth's.[1] Passing over this scientific faith, in the meantime, as a heritage he received from the past but had not examined, we find him boldly venturing to dispute the conclusions arrived at by Galileo, Hevelius, and others of great name. Galileo had made the lunar mountains higher than any then known on the earth, five and a half miles; but Hevelius reduced this

[1] In 1762, Samuel Dunn, from "a nice examination of the two ends of Saturn's ring, at such time when the planet is on the dark edge of the moon," came to the conclusion "that this diversity of appearance must have arisen from the effects of an atmosphere of the moon." Previously, he states, the existence of an atmosphere was much debated, and is "still undecided" (*Phil. Trans.* for 1761-2, vol. lii. p. 580).

In a paper read before the Royal Society on November 27, 1766, the Prince de Croy expresses doubts about the existence of a lunar atmosphere, but "I am inclined to believe," he says, "there is no water in the moon." He also states that the hollows between the mountains marked on his diagram are surprising on account of their depth.

estimate to about three miles and a quarter. Herschel attacked the problem, armed with a telescope of six feet eight inches focal length, which he speaks of as "a very excellent instrument, equal to any that was ever made." He brought to it also the same "uncommon diligence and attention," which made up in some measure for the imperfect instruments of previous astronomers; and he had confidence in himself, in his eyesight, and in the goodness of the work he had done.

He was struck by the "deep shadows" cast by mountains on the moon's surface. Probably these shadows were then a puzzle to him. But he made one sagacious observation, which subsequent observers have developed into a view of the moon's face altogether different from what he started with. On *Mons Lacer* he writes: "I am almost certain there are two very considerable cavities or places where the ground descends below the level of the convexity, just before these mountains." The moon's face is now known to be pitted with hollows of great extent and depth. Herschel's predecessors called them seas and oceans, of which there are none on the moon. The hills and mountains that rise from these vast cavities do not at the utmost greatly exceed the estimate come to by Herschel, a mile and a half, or a mile and three-quarters in height. But if the height be reckoned above the hollow from which they rise, it may be nearer three times as much. We count the heights of mountains on the earth from the level of the sea. If we reckoned from the bottom of the ocean, our mountains will be found considerably to exceed in height those of the moon. It is now known that these

cavities in the moon are from ten to seventeen thousand feet in depth, that they are surrounded by a great rampart or wall, a hundred, two hundred, or two hundred and fifty miles round, and that the mountains which rise from the floor of the cavity may be about a mile or a mile and a half high.[1]

His study of the moon's face led him, two years after, to believe that, from his far-off station near Windsor, to which he had then removed from Bath, he was looking down one night into the depths of the boiling crater of a volcano in the moon. A discovery so singular was not a thing to publish till he had full assurance of its accuracy. Four years after, he believed he had obtained evidence sufficient to warrant publication. Others, well qualified to judge, were of the same opinion. Among them was a gentleman from the Göttingen Society, to which Herschel the year before had taken the King's present of a 10-feet reflector. Writing to a friend in Paris, that gentleman says :—

"*May* 30.

"SIR,—Mr. Herschel has lately made a discovery of the greatest consequence, of which I have had the good fortune to be an eye-witness. He had observed last month, one or two days after the new moon, in the dark part of it, three luminous points. Two of these

[1] Moretus is a circular depression 120 kilometres across (80 miles), with an isolated mountain in the centre of nearly 7000 feet in height, the most considerable of its kind on the moon (*Atlas Photographique de la Lune*, Paris 1898, c. 56). The depths of the cavities are frequently very great, Tycho, for example, 5500 metres, or nearly 18,000 feet (c. 30, c. 55). Some of the mountain masses or tablelands are 5000 metres, 6600, and 7100, judging from the shadows they cast, or 16,000, 21,000, or 23,000 feet (c. 55, 56).

points were near each other, and their light was pale and weak. The third, which he judged to be about three English miles in diameter, exhibited a much stronger and a redder light. This he compared to a burning coal covered with ashes. These points he immediately conceived to be burning mountains, the two first being either nearly extinguished or beginning to burn, and the other in a state of actual eruption. Mr. Herschel did not fail to communicate his observation to the Royal Society; and the philosophers in this metropolis waited impatiently for the next new moon, which would necessarily confirm the observation, because the eruption would probably not continue above a month, and consequently the phenomena would be then very different, if Mr. Herschel's conjecture was well founded. Friday last, the 18th, the first day of the new moon, several philosophical gentlemen attended Mr. Herschel at his house in the country; but the weather was too cloudy to permit any observation. The next day I did myself the honour to visit him, with two of my friends. Fortunately, the sky was perfectly clear. After having examined, during two hours, the enlightened part of the moon, by means of Mr. Herschel's astonishing instruments, of which it is impossible to form an adequate idea without having seen them, we directed the telescope to the dark part of this satellite, and the conjecture of this great astronomer was instantly confirmed. The two first-mentioned luminous points had totally disappeared, and the fire of the other was become pale and weak. The diameter of its crater was increased to about six miles. Next month it will probably be entirely invisible. This discovery of volcanoes in the moon is a

proof that the matter of which it is composed is similar to that of our earth, and also proves the existence of a lunar atmosphere, which some philosophers have doubted. The science of astronomy is therefore infinitely indebted to the zeal of Mr. Herschel.

"This phenomenon was also seen by Count Bruhl, Mr. Cavendish, Mr. Aubert, etc.—Yours, etc., Z. Z."[1]

Lalande, of the Royal College of France, told a somewhat more wonderful story to the scientific world in a paper which he wrote for the Academy of Dijon. "Herschel," he says, "has seen in the moon two peaks or mountains formed almost before his eyes; there are in their neighbourhood certain currents resembling those torrents of lava that flow from a volcano at the time of its greatest eruption. This observation was confirmed by an actual eruption very visible in his telescope of 9 feet: it is a fire or light like that of a star of the fourth magnitude seen by the naked eye, and it appeared on the obscure part of the moon. This may help to explain the observation of Ulloa, who, in the total eclipse of 1783, saw in the middle of the moon a luminous point, which he conjectured to be a perforation." Alas for the astronomers who probably saw what they devoutly wished to see—a volcano in action on the moon! It was all moonshine, apparently a reflection of light from our earth, when sixteen times the amount of light showered on us at full moon is then thrown by us on her! But a hole through the middle of the moon, perhaps twenty miles round! There is no air that we know of on the half of the moon that we see, and there is no water. There are

[1] *Scots Magazine*, vol. xlix. 318, quoted from *Gentleman's Magazine*.

ample traces of volcanic fires that once lighted her surface, but they are all long gone out, and have left nothing behind for us but insoluble problems and mysterious wonders—a world of craters, lava, precipices, and cinders. That astronomers were mistaken was no discredit to them. They stumbled in the race for knowledge. That was all. If the reports of moving masses, still said to be seen in the moon, be confirmed, there may not have been much of a stumble after all.

While the observatories of Europe took a serious view of these volcanoes and lava rivers in the moon, the wits of London, and the King's equerries at Windsor, were making fun of the whole thing, and turning the batteries of ridicule on William Herschel. Tea in the room of the wardrobe ladies at Windsor Castle, especially with Mr. Bryant, the antiquary and author in the company, "was extremely pleasant." It was always antiquities or odd accidents with him: "This night, Dr. Herschel and his newly discovered volcanoes in the moon came in for their share." Next evening three equerry colonels were at table. The volcanoes again came into the eyes or lips of some of the party. "I don't give up to Dr. Herschel at all," cried Colonel Manners; "he is all system, and so they are all; and if they can but make out their systems they don't care a pin for anything else. As to Herschel, I liked him well enough till he came to his volcanoes in the moon, and then I gave him up: I saw he was just like the rest. How should he know anything of the matter? There's no such thing as pretending to measure at such a distance as that." The company sat silent while this outburst of lava,

which was at once both right and absurdly wrong, was coursing along the table. The lava had cooled, its heat was forgotten, when Colonel Welbred quietly interjected, "Sir Isaac Newton had been as much scoffed and laughed at formerly as Herschel was now; but, in return, Herschel, hereafter, would be as highly reverenced as Sir Isaac was at present." To it they again set. Someone remarked that "upon the heat in the air being mentioned to Dr. Heberden, he had answered that he supposed it proceeded from the last eruption in the volcano in the moon." "Ay," cried Colonel Manners, "I suppose he knows as much of the matter as the rest of them; if you put a candle at the end of a telescope, and let him look at it, he'll say, What an eruption there is in the moon!"

"But Mr. Bryant himself has seen this volcano from the telescope."

"Why, I don't mind Mr. Bryant any more than Dr. Heberden; he's just as credulous as t'other."

And thus the equerries wrangled at Windsor, while the rest of the world wondered or laughed at these volcanoes in the moon.[1]

Herschel's belief in an atmosphere of the moon was a heritage, a traditional heritage from the past. Had he fully examined the grounds on which the tradition was based, he would have opened a field of inquiry that remained closed for nearly a century and a half. In the total eclipse of the sun which happened in Switzerland on the 12th of May 1706, the red flames and the corona, features of an eclipse now known to everybody, were observed, apparently for the first time. Captain Stannyan, who was at Berne with the

[1] Miss Burney, *Letters*, iii. 375–380.

British Envoy, wrote that very day: "The sun was totally darkened for 4½ minutes of time; a fixed star and a planet appeared very bright; and *his getting out of the eclipse was preceded by a blood-red streak of light, from its left limb; which continued not longer than* 6 *or* 7 *seconds of time*;[1] then part of the sun's disk appeared, all of a sudden, bright as Venus was ever seen in the night; nay, brighter, and in that very instant gave a light and shadow to things, as strong as moonlight uses to do." Flamsteed adds his own comment on this strange story: "The Captain is set down as the first man ever heard of that took notice of a red streak of light preceding the emersion of the sun's body from a total eclipse. And I take notice of it to you, because it infers that *the moon has an atmosphere*; and its short continuance of only 6 or 7 seconds of time, tells us that *its height is not more than the* 5 *or* 6 *hundredth part of her diameter*," that is, about four miles.

At Geneva the same eclipse was viewed by a friend of Sir Isaac Newton, Facio Duillier, who, apparently, did not see the "blood-red streak," but gives a good description of the Crown, or as it is now called, the Corona. "The clouds," he says, "did change of a sudden their colour, and became red, and then of a pale violet. There was seen, during the whole time of the total immersion, a whiteness, which did seem to break out from behind the moon, and to encompass it on all sides equally. The same whiteness was but little determined, in its outward side, and was

[1] In the total eclipse of the present year there was seen "a brilliant display of carmine-coloured prominences extending over an arc of at least 60 deg." (*Times*, June 1, 1900, p. 10).

not broad the twelfth part of the diameter of the moon. This planet did appear very black, and her disk very well defined, within the whiteness, which encompassed it about, and whose colour was the same with that of a white crown or *halo*, of about four or five degrees in diameter, which accompanied it, and had the moon for its centre. . . . A little time after the sun had began to appear again, the whiteness and the crown, which did encompass the moon, did entirely vanish."[1] Duillier's comment on this description of the corona is: "The moon's atmosphere cannot well be supposed less than of 130 miles, in perpendicular height. . . . Though it was very plain that the atmosphere of the moon must needs show itself, in the time of a total eclipse of the sun; yet I do not know that anybody did think of this, till in the last month of May, many persons did actually see it."[2]

At Zurich Dr. Scheuchzer, in four lines of Latin, describes how they had a solar eclipse, at once total and annular; total, because the sun was wholly covered by the moon; annular, not properly so called, but by refraction, since around the moon appeared a ruddy brightness (*fulgor rutilans*), caused by rays refracted through the moon's atmosphere.

The blood-red streak, the corona, the ruddy brightness observed during the total eclipse of 1706, the

[1] A letter from a friend at Marseilles informed Duillier that, during totality, "there did remain one bright digit, all about the globe of the moon" (*Phil. Trans.* (No. 306), p. 2237).

[2] "The red prominences were first seen during the solar eclipse of 8th July 1842" (Proctor, *Encyc. Brit.* vol. ii. p. 788). Baily was not the first to see them. Captain Stannyan and Dr. Scheuchzer carried off the honour 136 years earlier. Facio Duillier has the credit of first describing the corona.

doubts about the moon's atmosphere, and the difficulties experienced in accounting for the crown, "or else concerning a meteor observed, not in our air, but in the vapours that encompass the sun," might have warned Dr. Halley and others to be especially watchful when a total eclipse was due in Britain on April 22, 1715. Halley admitted the points named to be "very singular, and deserving a great deal of attention." He believed that a total eclipse of the sun had not been seen in London since March 20, 1140 A.D. He passes a gentle censure on the French astronomers for their indifference to the total eclipse of 1706, but excuses them on the ground that it was the first which "had been observed with the attention the dignity of the phenomenon requires." Strange to say, he made no preparation to watch for "the blood-streak" and "the luminous ring" that crowned the black body of the moon, when the chance of seeing them again was presented in 1715. They were seen and described by him with a singular turning aside from facts to fables about the moon's atmosphere, and the vapours that were raised or the dews that fell on her surface. Here is the account Halley gives of the red clouds and the luminous ring in the eclipse of 1715:[1]—

"A few seconds before the sun was all hid, there discovered itself round the moon a luminous ring, about a digit, or perhaps a tenth part of the moon's diameter in breadth. It was of a pale whiteness or rather pearl colour, seeming to me a little tinged with the colours of the *Iris*, and to be concentric with the moon, whence I concluded it the moon's atmosphere. But the great height thereof far exceeding that of our

[1] "Dews," *Phil. Trans.* xxix. p. 248.

earth's atmosphere; and the observations of some, who found the breadth of the ring to increase on the west side of the moon as the emersion approached, together with the contrary sentiments of those whose judgment I shall always revere, makes me less confident, especially in a matter whereto I own I gave not all the attention requisite.

"Whatever it was, this ring appeared much brighter and whiter near the body of the moon than at a distance from it; and its outward circumference, which was ill defined, seemed terminated only by the extreme rarity of the matter it was composed of; and in all respects resembled the appearance of an enlightened atmosphere viewed from far; but whether it belonged to the sun or moon I shall not at present undertake to decide.

"During the whole time of the total eclipse I kept my telescope constantly fixed on the moon, in order to observe what might occur in this uncommon appearance: and I found that there were perpetual flashes or coruscations of light, which seemed for a moment to dart out from behind the moon, now here, now there, on all sides; but more especially on the western side before the emersion; and about two or three seconds before it, on the same western side where the sun was just coming out, a long and very narrow streak of a dusky but strong red light seeemed to colour the dark edge of the moon; though nothing like it had been seen immediately after the immersion. But this 8th antly vanished upon the first appearance of the the l as did also the aforesaid luminous ring."[1]

the h he eclipse of July 7 (8), 1842, Baily writes: "The breadth of the describ m the circumference of the moon was nearly equal to half of

Halley adds to this beautiful description that the darkness was "more perfect," and the stars seen were more numerous, in some places than in others; but "the light of the ring was to all alike." From the north of England, too, he heard "that the luminous ring round the moon was seen there, which was nowhere visible but while the eclipse was total"! Nine years before Halley conjectured that the cause of the corona or ring lay, "probably, in those very vapours, which produce that pointed light, that has been observed lying in a manner along the ecliptic, and that has the sun for centre," the zodiacal light.

Into this traditional heritage of a lunar atmosphere Herschel passed, till the blindness of unreasoning belief was dispelled by facts. His atmosphere of the moon, his three volcanoes on its surface, and its fitness as a home for life, similar to what exists on the earth, were long cherished beliefs, that had all to be unlearned. Had the knowledge acquired from the total eclipses of the sun in 1706 and 1715 not been laid on the shelf and forgotten, he would not have fallen into these mistakes. Unfortunately, though twenty-eight solar eclipses occur every eighteen years somewhere on earth, no total eclipse has been seen from our island since 1715. A few years passed away, and, in 1792, Herschel came to the conclusion that we "have great reason to surmise that the moon's atmosphere," as well as that of Saturn's fifth satellite, is "extremely rare."

the moon's diameter. Its colour was quite *white*, not pearl colour, nor yellow, nor red, and the rays had a vivid and flickering appearance, somewhat like that which a gas-light illumination might be supposed to assume if formed into a similar shape" (*Astron. Trans.* xv. p. 5).

Halley's account of what he saw in 1715 is as distinct and vivid as that of Baily in 1842. See also Lalande, ii. 443.

CHAPTER V

THE DISCOVERY OF URANUS

THE third paper sent by Herschel to the Royal Society was in the form of a letter to Dr. Watson from Mr. William Herschel of Bath, dated October 18, 1780. It was a record of observations made in the three years from 1777 to 1779, with the view of determining whether our day is of the same length year after year. A point so difficult could be settled, he thought, only by observing the length of the day in other planets. This had been done, or attempted, for Venus and Jupiter, by watching the time it took for a spot on the face of the planet to return to the same position. But in Venus, on account of her exceeding brilliance, it had been done so imperfectly that her day was put down roughly as of 23 hours' length. For Jupiter the time of rotation on his axis was set down more precisely at 9 hours 56 minutes, a result arrived at by keeping careful watch on spots that may not be fixed points on his disc, but movable on what we may call trade-wind belts of clouds in his equator. These spots "change so often that it is not easy, if at all possible, to ascertain the identity of the same appearance for any considerable length of time." Sometimes a bright, at other times a dark spot, or belt, was observed, but the time of its revolution round the

planet varied so much that no reliance could be placed on the result as a means of ascertaining whether our day remains the same from age to age.

Herschel considered the planet Mars a more favourable field for experiment than Jupiter. On Mars he saw spots of a different nature: "Their constant and determined shape, as well as remarkable colour, show them to be permanent and fastened to the body of the planet. These will give the revolution of his equator to a great certainty, and by a great number of revolutions, to a very great exactness also." A circumstance, with which Herschel was not acquainted, materially helped him in his observations on Mars. The atmosphere on that planet is not nearly so dense as the earth's, and similar trade-wind belts to those on Jupiter do not seem to exist. By these means he concluded that the length of a day on Mars is a little longer than our day, or 24 hrs. 39 min. 5 sec.[1] The value of an accurate measure of the length of day in other planets he conceived to be this: "Future astronomers may be enabled to make some estimate of the general equability of the rotatory motions of the planets. For if in length of time they should perceive some small retardation in the diurnal motion of a planet, occasioned by some resistance of a very subtle medium in which the heavenly bodies perhaps move, or, on the other hand, if there should be found an acceleration from some cause or other, they might then ascribe the alteration either to the diurnal motion of the earth, or to the gyration of the other planet, according as circumstances, or observed phenomena,

[1] Time of rotation determined since Herschel's days, 24 hrs. 37 min. 22·7 secs.

should make one or the other of these opinions most probable." This man could think, could reason and observe: he had also unusual powers of imagination: but he was only beginning his travels through the infinitudes of space and time.

Three papers for the Royal Society in the course of ten months! The musician of Bath puts himself at once on a level with the first men of science in the kingdom. He is modest, but he has in him the confidence of true genius. In his retirement he had been collecting facts from the heavens for six or seven years. A chance of speaking out what he saw and had gathered together was presented to him. He seized it with all eagerness, and was making his voice heard. In these papers he has been speaking to the Royal Society, of which he was not even a member. When he speaks next, about three months after, it is not as the musician of Bath, but as a member of the Royal Society; and he speaks to the whole world and to all time. This paper, which was read on April 26, 1781, and is headed "Account of a Comet," was really the beginning of modern astronomy. It fills only ten pages of the *Transactions*.

He had been engaged for some time in an attempt, not altogether novel, but certainly demanding great labour, to find out the distance of the fixed stars. His thoughts and plans were high, for though more than a century has passed since then, the distances of not more than twenty or thirty out of many millions can be said to be known, or perhaps safely guessed. While thus engaged, *rummaging* among the stars, "on Tuesday, 13th March, between ten and eleven in the evening, he perceived a star, in

the neighbourhood of H Geminorum, that appeared visibly larger than the rest. Being struck with its uncommon magnitude, he compared it to H Geminorum and the small star in the quartile between Auriga and Gemini, and finding it so much larger than either of them, suspected it to be a comet. . . . The sequel has shown that my surmises were well founded, this proving to be the comet we have lately observed." By the method he followed he was "enabled to distinguish the quantity and direction of the motion of this comet in a single day, to a much greater degree of exactness than could have been done in so short a time by a sector or transit instrument; nay, even an hour or two were intervals long enough to show that it was a moving body, and, consequently, had its size not pointed it out as a comet, the change of place, though so trifling as 2¼ seconds per hour, would have been sufficient to occasion the discovery." Satisfied that he had done all he could do, Herschel concluded his paper by saying, "I failed not to give immediate notice of this moving star, and was happy to surrender it to the care of the Astronomer-Royal and others, as soon as I found they had begun their observations upon it." The moving star was not a comet. It was a wanderer, who had been seen before and classified as a fixed star. The planet was what is now called Uranus.

The announcement of the discovery sent a flutter of excitement through all the observatories of Europe, which went on increasing when it was found that they could not agree on what or who the stranger was. Almost from its first appearance English astronomers believed it to be a planet that had long been wanted

to account for difficulties in their art. The French astronomers held to their faith in a comet moving round the sun in an orbit nearly circular. Herschel, praised everywhere as an observer "of great ardour and ingenuity," stood aside from the friendly strife. All observers were in debt to Bode, who found that a star, marked No. 964 in Mayer's catalogue, had been observed by him in 1756, had then been lost sight of, and was probably the stranger. Abbé Boscovich is said to have been the first to prove that the orbit was an ellipse; but to Lexell, Professor of Astronomy at St. Petersburg, is assigned the honour of showing that the newly found body was not a comet, but a planet, distant from the sun about nineteen times as far as the earth.[1] All with a name for science, from Laplace downward, took part in the friendly strife.

It has been said that this discovery was an accident; it has been also said that, if Herschel had not made it at the time he did, some other observer would before long have had the luck to fall in with the stranger. These criticisms are not creditable to those by whom they were made. Call it accident or chance, the fact remains that this novice, looking out for what he could find in the heavens, and with instruments improved by himself, discovered an unknown planet, and extended the boundaries of the solar system to twice the distance that had been received for thousands of years. Such accidents bring fame, and are only called luck by the envious.

One of the last-found planets of our solar system was discovered about a year ago, also by accident, but to the great honour of the discoverer. He was looking

[1] Robison, Edin., *Phil. Trans.* i. 305.

for something else; he found what he was looking for, and a new planet besides. What he was looking for was one of the so-called nuisances of the heavens, an asteroid, one of about 450, named 433[d]. To search for it as Herschel had to do, even though its whereabouts was known, called for labour and time. The astronomer, who was on the lookout for it, lessened both by exposing a photographic plate to the starry sky. He was spreading a net to catch planets and comets. A fixed star does not change its place during the exposure of the plate, or, rather, the plate moves as the star moves: a moving body, be it planet or comet, does change its place. A point will thus represent a fixed star; a line, however short, and however faint the trace, represents a moving body. When Herr Witt examined the exposed plate, he saw at once the trace left by the asteroid he was in search of; but another, a fainter and a longer trace of a moving body, was also seen on the plate. It was the trace of a planet hitherto unknown. An examination of the stranger resulted in the discovery that he was a ball twenty miles in diameter, and, excepting our moon, the nearest of the planets to us, so near that he may be made to tell us the exact distance we are from the sun. His discoverer called him Eros, Love or Cupid, evidently from his childish size.[1] Herschel had no such short-cuts to discovery in his day.

An immense impulse was given to the study of the stars by Herschel's discovery. It was not merely what he achieved by being on the spot and on the lookout. It was also by the lesson he taught astronomers to do as he did. A band of twenty-four

[1] *Nineteenth Century*, April 1899, p. 612.

observers, suspecting, and with good reason, that a well-kept watch would reveal unknown wonders in the depths of space, undertook to search for other planets. Had photographic plates or charts then been part of the equipment of an observatory, the work would have been easy, and the reward certain. But plates and star-charts were not known; and the twenty-four workers laboured and toiled in vain. An outsider carried off first honours on the first day of the century—Piazzi of Palermo, who had visited Slough, had talked with Herschel and his sister, and perhaps drawn a breath of inspiration from them and their surroundings. The beaten twenty-four astronomers did not retire from the field. Two years later, Dr. Olbers, of Bremen, discovered another asteroid, Pallas; and two years later still, Harding, in the same neighbourhood, discovered a third, Juno. Olbers, wisely using imagination in the pursuit of science, came to the conclusion that these small bodies were pieces of a planet which had burst or exploded, and that other pieces would be found floating about in space. He acted on the idea, and rediscovered Piazzi's Ceres, which had been lost again, as well as a fourth asteroid, Vesta. Then the hunt for more pieces of the disrupted planet ceased, till, about forty years later, it again received a fresh impetus from Hencke's discovery of Astræa, and was continued by Mr. Hind at the Regent Park Observatory in London, and others, with such success that floating pieces have been netted by hundreds, grumbled at as nuisances, and assigned the honour of having been thrown off direct by the sun himself, not blown into space by a disrupted planet. One of these pigmy planets was named Lucretia, after

Herschel's sister. Such were some of the fruits of William Herschel's earliest studies among the stars.

The nature of the wandering stranger discovered on March 13, 1781, was not fully known for some months. Herschel had surrendered the care of his new world to the astronomers of Europe, and they could not make up their minds about it, till Lexell of St. Petersburg led the way by showing that it was an outlying primary planet. A whole year elapsed, and Herschel had resumed his observations on this "singular star" before he thought of giving it a name. Events had happened during the interval which affected his view of the name it should bear: he had become Royal Astronomer to George III., had received from him a yearly pension, was pursuing a profitable trade as a maker of telescopes under the King's patronage, and was housed under the shelter of Windsor Castle. It should cause no surprise, therefore, that, evidently after long consideration, he addressed the following letter to Sir Joseph Banks, President of the Royal Society:—

"To Sir Joseph Banks, Bart., P.R.S.

"Sir,—By the observations of the most eminent astronomers in Europe it appears that the new star, which I had the honour of pointing out to them in March 1781, is a primary planet of our solar system. A body so nearly related to us by its similar condition and situation, in the unbounded expanse of the starry heavens, must often be the subject of the conversation, not only of astronomers, but of every lover of science in general. This consideration then makes it necessary to give it a name, whereby it may be distinguished from the rest of the planets and fixed stars.

"In the fabulous ages of ancient times the appellations of Mercury, Venus, Mars, Jupiter, and Saturn were given to the planets as being the names of their principal heroes and divinities.[1] In the present more philosophical æra, it would hardly be allowable to have recourse to the same method, and call on Juno, Pallas, Apollo, or Minerva for a name to our new heavenly body. The first consideration in any particular event, or remarkable incident, seems to be its chronology: if in any future age it should be asked, *when* this last-found planet was discovered? it would be a very satisfactory answer to say, 'In the Reign of King George the Third.' As a philosopher then, the name of GEORGIUM SIDUS presents itself to me, as an appellation which will conveniently convey the information of the time and country where and when it was brought to view. But as a subject of the best of Kings, who is the liberal protector of every art and science;—as a native of the country from whence this Illustrious Family was called to the British throne;—as a member of that Society, which flourishes by the distinguished liberality of its Royal Patron;—and, last of all, as a person now more immediately under the protection of this excellent Monarch, and owing everything to His unlimited bounty;—I cannot but wish to take this opportunity of expressing my sense of gratitude, by giving the name Georgium Sidus,

'Georgium Sidus
—jam nunc assuesce vocari' (Virg. *Georg.*),

to a star, which (with respect to us) first began to shine under His auspicious reign.

[1] Herschel might have known better than write this: see M. de Lalande's *Astronomy*, secs. 639, 640.

"By addressing this letter to you, Sir, as President of the Royal Society, I take the most effectual method of communicating that name to the Literati of Europe which I hope they will receive with pleasure. I have the honour to be, with the greatest respect, etc.,

"W. HERSCHEL."

When Herschel discovered the planet Uranus he had received no favour and no bounty from King or people. Nor did the King extend his patronage to him till fifteen months had elapsed. Galileo was in receipt of a handsome allowance from the Grand Duke of Tuscany, when he discovered the satellites of Jupiter, and called them the Medicean Stars. It was not only pardonable to do this; it was most natural. But science refused to endorse the flattery: and scientific men, especially on the Continent, were equally unwilling to accept the name proposed by Herschel for the newly discovered planet. For many years it continued to be called the Georgian Star, or the Georgium Sidus, in this country, though not without strong protests. While scientific men in Britain allowed that "George the Third has many titles to be remembered by the friends of science, to which few of his contemporaries have any pretensions," they maintained, "We shall therefore do well to anticipate the decision of posterity, by at once adopting a term that must ultimately prevail." No one thinks of perpetuating the name Georgian now. Uranus has displaced it, and justly. The judgment of posterity has gone against the name proposed by the discoverer and that of *Herschel*, generously proposed by Lalande. Heathenism and antiquity have carried the day. Everyone must decide for himself whether

this was right, or whether the same rule should hold among the stars as has been allowed to hold on earth, where an adventurer gives his name to a New World, and the real discoverer has to rest content with naming a province of it, perhaps a province of little worth.

In writing this letter to the President of the Royal Society, William Herschel could plead more grounds for justification than we might be disposed, at first sight, to allow. That he was recognised by the King as a discoverer and a leader of thought was a great honour, recommending him at once to the nation and to the whole world. That he was paid a salary out of the King's or the nation's purse, and was placed by the King near the palace and brought into close relations with the Royal Family is also manifest. We are bound to give due weight to these considerations in the mind of an upright and honourable man, who deeply respected his sovereign, and knew best the amount of his own indebtedness. But history tells more than one story, that goes far to justify Herschel's name for the newly discovered star. It was not an uncommon thing to exalt an earthly prince to a throne in earthly skies. Probably we shall all admit that this was a mistake, perhaps a degradation of true science, which knows no distinction between king and beggar, and whose boundaries have been extended, to quote the words of Galileo, a hundred thousand fold by those whom popes and princes despised. But the fact is beyond dispute. The hair of Berenice, the Queen of Egypt and the murderess of the lover by whom she was slighted, was carried off from the temple of Venus, to whom it was vowed, and placed by Conon as a constellation among the stars. Sobieski,

the valiant deliverer of Eastern Europe from the Turkish power, got a similar honour done him by Hevelius in the then invented constellation called Sobieski's Shield. Galileo felt himself under such obligations to the ducal house of Tuscany that he named the four moons of Jupiter, which he discovered, the Medicean Stars, a name they long continued to bear. The honour of a place in the heavens was great. It was also much sought after, so much so that Galileo was told "he would do a thing just and proper in itself, and at the same time render himself rich and powerful for ever," if he "named the next star which he should discover after the name of the great star of France, as well as the most brilliant of all the world," Henry of Navarre. Fortunately, in this respect at least, he had not the chance, otherwise we might have had the starry heavens peopled with the princely nonentities of earth. Royer, in 1679, did a similar honour to Louis XIV., by forming a constellation, called The Sceptre, for that monarch's glory; Messier, after the astronomer of that name, was another recently invented constellation on which Boscovich made the lines—

> "Sidera, non Messes, Messerius iste tuetur;
> Certe erat ille suo dignus inesse polo."

But no one would have expected a man of science so famous as Edmund Halley, to invent a constellation in honour of Charles II., The Oak, in memory of his escape after Worcester, or that Flamsteed would have placed so rotten a thing as the "Heart of Charles II." among the stars.[1]

[1] Lalande, i. 283, 284.

While we are satisfied that there is no ground for finding fault with Herschel's name for the new planet he discovered, we are more satisfied that, by the mouth of Bode, the jury, to whom he required to appeal, disallowed the flattery, and called the planet Uranus, not even *Herschel*, as Lalande proposed. The next planet that was discovered, the first of the asteroids, was named by its discoverer *Ceres Ferdinandea* after a contemptible King of Naples, but *Ceres* has long since swallowed *Ferdinandea* up. Even at the time an amused cynicism, speaking in the *Letters* of Horace Walpole, was saying, "Must not that host of worlds be christened? Mr. Herschel himself has stood godfather for His Majesty to the new Sidus. His Majesty has a numerous issue; but they and all the princes and princesses in Europe cannot supply appellations enough for twenty millions of new-born stars." [1]

In the year 1782 Herschel not only continued to prosecute the studies he had begun, but ventured into new and almost untrodden fields of research. Two or three months were cut out of the working time of that year by a summons to Windsor to see the King and hear what he might do for him. But his activity and enjoyment in work made up for lost time. In 1780 he contributed two papers, or twenty-five large pages, to the *Philosophical Transactions of the Royal Society*; in 1781 he contributed two papers, or thirty-five pages; and in 1782, notwithstanding the loss of two months, four papers, or nearly one hundred pages—a good year's scientific work for any man, more especially for one who was giving thirty or even thirty-eight music

[1] *Letters*, vi. 259.

lessons to his pupils per week; groaning and fretting under the incapacity of not a few of them—a man who had to be in his place conducting a band or a concert, and supervising a church's music, or who, instead of seeking rest in sleep, when the day's weary work was done, would often spend the night in observing the stars. His sister, who was his invariable companion in these night watches, had ample reason to say of him, "He did in one season more than anyone else could have done, and would have resumed the *hunt* [for Saturn's satellites] the next fifteen years, if nothing had interfered."

The new path on which he entered, and which led him into other and most attractive fields of inquiry, was the distance of what are called the fixed stars from the solar system. He knew that at the distance of the nearest of them, twice the sun's distance from the earth, immense though it seems, appears no bigger than a needle point, and cannot be used as a base line for measurement, or, indeed, as a line at all. He gave up the thought of attempting to solve the problem from that, the most natural and the easiest side. It was good for neighbours so near us as Mars and Venus. It was useless for Sirius or Arcturus. Following, perhaps, the example of Galileo, he believed that observations on stars so close together that neither the naked eye nor ordinary telescopes could separate them, and make two out of one, would lead to a discovery of their distance. He did not succeed in his purpose, but he was "introduced to a new series of observations and discoveries." He resolved to examine every star in the heavens with the utmost attention and a very high power, that he might collect such

materials for this research as would enable him to fix his observations upon those that would best answer his end. The subject promises so rich a harvest that he cannot help inviting every lover of astronomy to join him in observations that must inevitably lead to new discoveries. He took some pains to find out what double stars had been recorded by astronomers; but "Nature, that great volume, appeared to him to contain the best catalogue upon this occasion."

The results of this search of the heavens appeared a month later in a *Catalogue of Double Stars*. They were "not only double stars, but also treble, double-double, quadruple, double-treble, and multiple." And he noticed, in a strangely prophetic vein of inspired imagination, not shrined in the temple of fact for more than twenty years after, "It is much too soon to form any theories of small stars revolving round large ones." Of 269 of the suns contained in this catalogue only 42 had been previously observed. While pursuing researches so laborious and so delightful, he was driven to devise ingenious improvements on the micrometer, as the contrivance was called that is used for measuring small spaces. But Herschel's thoughts were turned into other channels in the summer of 1782. He was raising questions we are only getting answers to now.

While Herschel was thus rapidly rising into fame, he was not forgetful of the sister who generously sacrificed her own wishes and prospects as a singer to advance his as an astronomer. During the time she was free from her numerous engagements as the thrifty housekeeper, the careful secretary and time-keeper, the reviser and reducer of observations, she

amused herself by sweeping the heavens for comets with a five-feet reflector, of which her brother had made her a present. She was so successful that her fame soon sounded over Europe. "Miss Herschel," one writer reports, "sister of the celebrated astronomer, has observed a comet, and its orbit has been calculated. This is the seventy-third comet of which we know the period." This celestial visitor was talked of in Windsor Castle as the Lady's Comet. Unfortunately, the name was not retained, as it ought to have been, or at least given to a later discovery by Miss Herschel. Between 1786 and 1797 she discovered eight comets altogether, but of only five was she the first discoverer. The seventh, seen by her on November 7, 1795, was specially worthy of this name, but is now known as Encke's Comet. Her value as an assistant to her brother, besides her own personal merit as a woman of science, got for her a pension of £50 from the Civil List, granted to the King by Parliament. It was sufficient for the modest wants of a woman who not only handled a telescope with the dexterity of a practised observer, but, when sixty years of age, spent some of the last days of her stay at Slough "in painting and papering the rooms she was to occupy in a small house of her brother's, attached to the Crown Inn, to which she removed."

Year after year, from 1780 to 1812, the active mind and the prolific pen of William Herschel enriched the *Proceedings of the Royal Society* with one or more papers, which astonished the world of science and attracted the attention of mankind. The years 1813, 1816 were blanks, but 1814, 1815, 1817, and 1818 showed no feebling of hand or eye, although for years

his strength had been failing under the pressure of burdens laid on him as King's Astronomer—unnecessary burdens. Without including the diagrams, often in themselves a heavy labour, these papers are spread over two thousand quarto pages, an extraordinary record of hard, honest, earnest work. His first two papers were said to be "communicated by Dr. Watson, Jr., of Bath, F.R.S., and written by Mr. William Herschel of Bath." The same designation of the astronomer appears again in the *Proceedings* for 1781; but in the end of the year it is replaced by Mr. Herschel, F.R.S. In 1783–84–85 we find, William Herschel, Esq., F.R.S. But from 1786, the year in which he received the degree of LL.D. from the University of Edinburgh,[1] to 1815, the style is, William Herschel, LL.D., F.R.S. In 1817, 1818, it becomes Sir William Herschel, *Knt. Guelp.*, LL.D., F.R.S. The musician of Bath had made good his right to rank with the noblest and the most learned of men.

[1] Professor Holden, in his *Life*, writes (p. 47): "It was only in 1786 that he became 'Dr. Herschel,' through the Oxford degree of LL.D." This Oxford degree of LL.D. has of late been changed in his case into D.C.L. The Oxford "Catalogue of all graduates . . . between Oct. 10, 1659, and Dec. 31, 1850," does not contain his name, except as the father of Sir John Herschel, on whom the degree of D.C.L. was conferred. The date of the Edinburgh degree is April 10, 1786, and is the only ground I can discover for the title LL.D., that he takes in all his papers from 1786 to 1818. The honour of LL.D. from Oxford was first claimed for Herschel in 1798–9. See *Public Characters*, i. 396.

CHAPTER VI

ENDOWMENT OF RESEARCH

It was clear to men of science that something had to be done for Herschel. He could not toil or slave as a teacher of music and a conductor of concerts during the working hours of the day, and improve the telescope or keep watch on the stars by night, without discredit to a nation that was proud of its maritime supremacy, and offered a large reward for the best means of finding the longitude at sea. Since the discovery of Uranus, his name was in everybody's mouth, especially in Bath. People of celebrity, with or without introductions, came to see him. Among them was the Astronomer-Royal, Dr. Maskelyne, who proved a steady and admiring friend. At their first interview, Caroline thought they were quarrelling. Eagerness to make sure that this musician was a reality, not a sham, may account for the high tone of voice that sounded to her like quarrelling, while her brother's remark when Maskelyne left, "That is a devil of a fellow," reads more like a compliment than a censure. Dr. Watson, between whom and Herschel a friendship had sprung up, that lasted for the remainder of a long life, was constantly at his house, helping to grind or polish, offering money to meet expenses, which was gently declined, and communicating papers and

letters from Sir Joseph Banks, President of the Royal Society. Herschel was rapidly outgrowing his surroundings. The dullest eye could see that something had to be done for the honour of the country. Herschel, though resident in England, was not an Englishman; but he was a subject of the King of England as Elector of Hanover, and the nation that reaped the honour, it might soon come to be the profit, of his discoveries, was bound to mark its sense of the value it set upon his presence within its borders. The Royal Society did what they could, but it was far from enough. As they honoured Benjamin Franklin with the Copley Medal in 1753 for "curious experiments and observations on electricity," so they showed their high regard for William Herschel by awarding the same medal to him in November 1781 for his "discovery of a new and singular star." On December 6 of that year he was also elected a Fellow of the Society. But these honours did not meet the case. They were prizes won in the race for fame; they did not provide a living or leisure for further triumphs. But the King personally was bound to interpose. He had a name throughout Europe for love of science, and especially of astronomy, which no other monarch enjoyed. A great French writer described him, long before Herschel appeared above the horizon, as "véritablement amateur de la Physique et de l'Astronomie." For years he had supported an observatory and a King's Astronomer at Richmond. Parliament had provided ample funds in the form of a Civil List, of which at that time it got no account. But the funds were squandered or spent with such a lavish hand that enormous arrears remained unpaid. Apparently the King was helpless.

Public opinion outside of scientific circles had also something to say about Herschel, for he had become a power and a wonder in the country. "Mr. Herschel's astronomical papers," it said, "have justly excited peculiar attention; and his account of a comet, or, perhaps, a new planet, hath procured for him the honour of Sir Godfrey Copley's Medal. Mr. Herschel, who is a musician at Bath, is one of those extraordinary men, whose genius for astronomy and whose talents for the improvement of instruments have enabled him to break through every disadvantage of situation, and to make discoveries which, as they call for the warmest approbation of mankind, ought to obtain for him a more than common encouragement and patronage."[1] A year later the same organ of public opinion wrote: "Mr. Herschel, of whom we spoke in our last volume, hath carried on his astronomical researches with amazing success. He hath discovered a great number of double and triple stars, which are surprisingly and beautifully diversified in their appearance and their colours. The new star or comet, for the discovery of which he obtained the Gold Medal in 1781, is now, without controversy, ascertained by him to be a regular primary planet, beyond the orbit of Saturn. He hath given it the name of the Georgium Sidus, in honour of the King, who hath settled a handsome salary upon him and taken him into his immediate service. This instance of Royal patronage and munificence to eminent scientific merit is equally glorious to His Majesty and to Mr. Herschel."[2]

The instincts of the writer were correct, but his

[1] *Annual Register* for 1781 [118].
[2] *Annual Register*, 1782 [219].

knowledge of "the handsome salary" was perhaps defective.

"Among the Bath visitors were many philosophical gentlemen, who used to frequent the levees at St. James's when in town. Colonel Walsh,[1] in particular, informed my brother that from a conversation he had had with His Majesty, it appeared that in the spring he was to come with his seven-foot telescope to the King. Similar reports he received from many others, but they made no great impression nor caused any interruption in his occupation or study," till "one morning in Passion Week, as Sir William Watson was with my brother, talking about the pending journey to town, my eldest nephew arrived to pay us a visit, and brought the confirmation that his uncle was expected with his instrument in town."[2] This nephew was George Griesbach, son of the elder daughter in the Herschel family, and a musician well known and favoured at Court. A chaise was at the door to take brother and sister to Bristol, ten miles away, for a forenoon rehearsal of the *Messiah*, which was to be performed in the evening. The conductor was too much absorbed in his nephew's news from Court to attend the rehearsal. Caroline was left to do it for him, and to fill "the music box with the necessary parts for between ninety and one hundred performers." This was how news of the endowment of research came from London to Bath. It was a reality, not a romance gilded with glory, like the news brought by an imaginary rider from Ghent to Aix. But the news, however

[1] Apparently one of the King's equerries, of whom we shall hear more in the course of the story.

[2] Caroline Herschel, *Memoirs*, p. 44.

satisfactory, came in so unsatisfactory a way, and were so long in bearing fruit, that something was at work behind the scenes delaying progress. It appeared that the King's private astronomer, Mr. De Mainborg, was dead. Herschel's friends imagined he was to succeed to the vacant post at Kew,[1] for George III. was known for his patronage of astronomy long before he heard of Herschel. In an observatory at Richmond, built under the superintendence of Bevis, 140 feet long and of two storeys, were several grand instruments made by Sisson of London.[2]

Laden "with everything necessary for viewing double stars," Herschel, accompanied by his friend, Sir William Watson, left home on May 8. No letter reached the anxious household at Bath for a fortnight. At last Caroline and Alexander learned that "he had been introduced to the King and Queen, and had permission to come to the concerts at Buckingham House, where the King conversed with him about astronomy." He was also so favoured that "the King gave him leave to come to hear the Griesbachs play at the private concert which he has every evening." Even his brother Alexander was known to the King, and was inquired after in the same breath apparently as he inquired after "the great speculum." Had Miss Burney been telling the story, she would probably have said that "What? what? what?" looked upon the two as creatures of the same kind. But his pupils and Mr. Palmer, the manager of the theatre at Bath, must be told that he could not return till the King had seen the planets with the seven-foot reflector, and given him permission to leave. That telescope had

[1] *Memoirs*, p. 321.

[2] Lalande, *Preface*, i. xxxvii.

found a temporary home in the Royal Observatory at Greenwich, where it put Dr. Maskelyne out of conceit with the instruments he had for national use, and, not long before, for exhibition, with handling by the public, at so much per head![1] Colonel Walsh again makes his appearance as entertaining Herschel at dinner with the Astronomer-Royal, and Mr. Aubert, a well-known observer of those days. Both of them were delighted with the new telescope and its inventor.

Maskelyne was provided at Greenwich with two mural quadrants of eight feet radius at a cost of £280 each, a great transit instrument, a sector of 12 feet, and many other instruments. An assistant also was kept constantly at work on the observations made. Astronomers allowed that at no place had so many good observations been made as at Greenwich, but Maskelyne was dissatisfied when he compared the instruments with the telescope of Herschel, the work of the ablest craftsmen in England with that of a novice.[2] On February 20, 1806, the French mathematicians, "notwithstanding the spirit of hostility that had so long animated England and France against one another," gave a most gratifying proof of the regard in which they held Maskelyne and his predecessors in the Royal Observatory at Greenwich. They wrote by De Lambre to Maskelyne, sending him seven copies of their newly published astronomical tables, and paying the homage of gratitude and esteem to "the author of the greatest and most precious collection of observations that exists." They were "deduced, by the rules of Laplace, chiefly from a series of more than three thousand two hundred observations made at

[1] Weld, ii. 28.

[2] Lalande, *Preface*, xxxvii. (1771).

Greenwich between the years 1765, 1793."[1] Science was thus the mother of peace and goodwill between two bitterly hostile nations.

An attack of influenza, which wore off in less than a week; a series of dinners, at which the new lion of science was exhibited to the gaze of "the best company," and little was talked "of but *what they called* his great discoveries"; two nights of star-gazing at Greenwich; state concerts, at which the King "kept him in conversation for half an hour," and even asked George Griesbach for a solo-concerto that his uncle might hear him play; acting the showman by explaining the speculum to the Princesses, and, on a cloudy evening, showing them, "with fine effect" through the telescope, a pasteboard Saturn at the bottom of the garden wall," —these and other tricks of this "showman of the heavens" were his employment for the next few weeks. "Company is not always pleasing," he wrote, "and I would much rather be polishing a speculum." In the midst of this mental dissipation he was brought down from heaven to earth by his money running short. Several times he wrote to Bath for a supply! Delays so unnecessary, and the thoughtless indifference with which a working musician was kept hanging on at Court, without regard to his loss or his expenses, were not creditable to those concerned. It looks as if there were a hitch somewhere.

His sister relates in a letter written in 1842, twenty years after his death, that the King was surrounded by *wiseacres*, who knew how to bargain. They proposed to send her brother back to Hanover on a salary of £100 a year. Her idea was that Parliament had

[1] *Edin. Rev.*, 1809, pp. 65, 69.

"granted to the King £80,000 a year for encouraging sciences." She also believed that West the painter and her brother were the first who benefited by this grant. She is referring, of course, to the arrangements regarding the Civil List, which came into effect in 1782.[1]

It seems to me that the King had more serious difficulties in dealing with William Herschel than are generally supposed. Unquestionably he had deserted the army of Hanover after a severe defeat, and in presence of an advancing enemy. A quarter of a century had passed since then; but could the Elector of Hanover, as King of Great Britain, pass over an offence so grave, and knowingly honour the offender even after that lapse of time? So long as it was simply letting bygones be bygones, the matter was easy of solution; but it came to have another look when the offender was received under the shelter of the palace, admitted to intercourse with the Royal Family, and paid a pension out of the King's purse. That the offence was unknown to the King is altogether improbable. He knew Herschel's younger brother, Alexander, and inquired after him at a state concert in Buckingham House. He knew also the Griesbachs, Herschel's nephews, and employed five of them at these concerts. A family from the town of Hanover, and of such outstanding ability, would be so much in the mouth of Hanoverians that echoes at least of their gossip could not fail to reach the King's ears. The King's knowledge of every petty detail of gossip among the Hanoverians had passed into a proverb in England. "Modern poets differ from the Elizabethans in this,"

[1] *Memoirs*, p. 321.

Keats wrote, while George III. was living: "each of the moderns, like an Elector of Hanover, governs his petty state, and knows how many straws are swept daily from the causeways in all his dominions, and has a continual itching that all the housewives should have their coppers well scoured."[1] It is manifest, too, that Herschel had no desire to return to his Hanover home, or even to the mother who aided him to escape in 1757, and was the foolish cause of many perplexities and troubles. In fifteen years his visits were few, only three apparently, and his stay was brief. There was something in the air of the place that disagreed with him. It may therefore be that the King required to consult his ministers in Hanover before he could overlook the offence of a young guardsman, who had now become an astronomer, with whose fame all Europe was ringing. For two months the uncertainty about William Herschel's future continued. Communication with Hanover on business of state in those days was conducted by a "quarterly messenger," who was sometimes delayed, even in George IV.'s reign, forty years after this time. Delay was thus perhaps unavoidable.[2] Clearly, the King or his advisers could not make up their minds what to do. At last they came to a decision in the way people do when in doubt. They split the difference, and made a bargain with Herschel unworthy of the King and the country. It looks as if Britain incurred odium for the sake of Hanover.

That the bargain included a pardon under the King's

[1] *Life*, February 3, 1818, i. 84.

[2] *Memoirs of Sir William Knighton*, i. 321 ; *Car. Her.* also, pp. 232, 240, 239.

own hand is asserted on what is called unquestionable evidence, and is in itself extremely probable from a story told of George IV. on his visit to Hanover in 1821. "Early in the morning," his physician-in-ordinary says, "a poor woman, with a countenance apparently much worn with sorrow, on her knees presented a petition to the King's Hanoverian chamberlain, which was rejected. I saw this from the saloon, from which I was looking down on the many thousand persons assembled in the courtyard, and I observed the expression of despair which followed. I hastened down, fearing to lose sight of her, got her petition, and presented it to the King.

"It craved his mercy for her husband, who was doomed to five years' hard labour in a fortress. She was the mother of eight little children, and, it need not be added, in great poverty and want. The crime was of a nature to be pardoned, and this was done with his pen instantly; for here his authority is absolute. We had the poor woman in the saloon, and you may imagine the rest."[1]

The view taken of the bargain at the time was given voice to by Caroline Herschel, and has since been frequently repeated to the King's discredit, without the retractation which she made after her brother's death. Here is the retractation. Writing to her nephew, in April 1827, she says:—"*P.S.*—I must say a few words of apology for the good King, and ascribe the close bargains which were made between him and my brother to the *shabby, mean-spirited advisers*, who were undoubtedly consulted on such occasions; but they are dead and gone, and no more of them! Sir J.

[1] Knighton, i. 169.

Banks remained a sincere, well-meaning friend to the last." Not many days after (May 8, 1827) she writes what it never occurred to her, apparently, might account for this alleged mean-spirited shabbiness: "When in 1758 he again went to England, it was under such unpleasant circumstances that he was obliged to leave it to his mother to send his trunk after him to Hamburg."[1] The nation or mob that shot Admiral Byng for incapacity four months before the Hanoverian bandsman deserted, that cashiered Lord George Sackville for less two years before, and that not only ridiculed the King's own uncle, "the poor Duke," as Cumberland was called, "the lump of fat crowned with laurel on the altar,"[2] but "were new grinding their teeth and nails to tear him to pieces the instant he lands,"[3] for a similar fault to Byng's, had to be reckoned with in bestowing honours on a deserter. So the King may have thought, and so his dilatoriness and apparent shabbiness may be accounted for, as well as the secrecy in which the affair was shrouded during their lives.

But there are circumstances which involve in still greater obscurity the whole of these so-called bargains between the King and William Herschel. Some years after the death of both, an English writer spoke of the ingratitude of England. But there is no proof that Herschel, though settled in England, was ever naturalised. His sister, so far as words could go, threw off her German nationality; but words are not law. "I was always sure to be noticed by the Duke of Cambridge as his countrywoman," she wrote in 1835, "(and

[1] *Memoirs*, p. 211. [2] Referring to a cartoon of the day.
[3] Walpole's *Letters*, iii. 475, 284.

that is what I want, I will be no Hanoverian!)"[1] That these sentiments were simply an echo of her brother's, we can scarcely doubt. As far also as is now known, "the bargains" made were not reduced to writing. Everything seems to have been done by word of mouth. In fact, George III. and his advisers dealt with Herschel, not as an Englishman but as a German. No English honours were bestowed on him, such as were bestowed on younger or less deserving men. Sir Humphry Davy received the honour of knighthood from the Prince Regent in 1812. He was forty years younger than Herschel. Dr. Smith, one of the founders of the Linnean Society, was knighted by the Prince two years afterwards, although he was not specially known as a man of science.[2] Two years later Herschel received a paltry honour, at least as Englishmen counted honours. There must have been reasons for this apparent neglect. But whatever they were, the truth remains that as far as can now be known, the rashness and anxiety of a woman of small capacity saved her son from the life of a musician in a Hanoverian regiment, not to his honour or hers certainly, and made a present of him to the cause of science with results of unspeakable honour to himself and the human race. The lad of nineteen who was induced by his mother to desert an army, led by an incompetent "lump of fat," as they then said, was no coward. He perilled life and limb too often in his work as an astronomer to be counted a poltroon as a soldier.

When George III. thus resolved to endow research in the person of William Herschel by appointing him Royal Astronomer at a salary of £200 a year, coupled

[1] *Memoirs*, p. 276. [2] Weld, *History*, etc., ii. 327, 198.

with permission to make and sell telescopes for his own behoof, and with the requirement that he should act as "showman of the heavens" to princes and princesses, it was neither an uncommon nor an ungenerous act in the world of science. It is presented to us in the gossip of the day as lacking in generosity, and reflecting small credit on the King and his advisers. The salary of Dr. Maskelyne, then Astronomer-Royal, and the head of the most famous observatory in Europe, a man of high standing to boot, and of world-wide scientific attainment, was only £300, to the discredit of the nation, not of the King. Besides, the Civil List from which, presumably, the pension was paid, was then in a transition and probably a crippled state. Two years before, Mr. Dunning moved in the Commons, and, after a feeble resistance, carried, "That it was competent to the House, whenever they thought proper, to examine into and correct abuses in the expenditure of the Civil List revenues." The Court required to be on its guard, as, in the very year the pension was granted to Herschel, the King sent a message to the Commons, "requesting a discharge of arrears of Civil List, amounting to nearly £296,000; the House voted the requisite sum." [1]

The endowment of research was far from being a new thing in Europe. It had been the work of princes; it was now becoming the work of parliaments and people. James I. when, in defiance of the witches of Scotland and Denmark, he crossed the North Sea to

[1] Adolphus, *History*, iii. 119, 372 (1780, 1782). By the Parliamentary regulations passed in 1782 "no pension was to exceed £300 a year" (15th April) (Cassell's *History*, iv. 290–91). In 1783 arrears were again accumulating (Cassell, iv. 301).

fetch home his bride, spent eight days under the roof of "that princely promoter of astronomy," Tycho Brahe. He found the astronomer living in comfort, encouraged by the splendid allowances of the King of Denmark, and able to build an observatory, which is said to have cost £20,000. Though always in straits for money, he not only honoured Tycho at his departure with "a magnificent present, but also addressed to him a copy of verses." One of James's grandsons, Charles II., appointed Flamsteed to be Astronomer-Royal at a salary of £100 a year. So inadequately was he paid that he had to eke out his income by taking orders in the Church of England. But James's great-grandson, William, was a more generous patron of science than his uncle. In his reign Newton received the post of Master of the Mint with a salary of £1200 or £1500 a year, at a time when the commercial interests of England required a man of great intelligence, honesty, and resource to rescue society from the embarrassments into which incompetence and gambling had plunged the Mint and the country. A man of ability was required to cope with the evils of the time, and Newton, in spite of the sneers with which his appointment was hailed even by Pope, proved himself to be the right man in the right place.[1] But the sneer cast at our Government was true then, and may still be true, as it was seventy years ago when first uttered, "Able men are sure of office when its emoluments are abolished." Men of science, men devoted to the best interests of their country, Dalton, Priestley, Ivory, Young, Wollaston, and Murdoch, to name no others, were treated with neglect, or considered well

[1] Macaulay's *Works* iv. 248.

paid if a Royal Society medal were awarded to them. Some, like James Watt, had even to save their own inventions from the grasp of unscrupulous claimants, who wished to rob them of the fruits of their genius. The result of this policy of indifference was plain to all who could see. "In England, whole branches of Continental discovery are unstudied, and, indeed, almost unknown, even by name. It is in vain to conceal the melancholy truth. We are fast dropping behind. In mathematics we have long since drawn the rein, and given over a hopeless race. In chemistry the case is not much better." These were the words of Sir John Herschel in 1830, fifteen years after the great war was ended, and could no longer be pleaded as a reason for our isolation and ignorance. Sir Humphry Davy, President of the Royal Society, spoke in the same terms and about the same time. Babbage, the inventor of the wonderful calculating machine, expressed views equally strong. "In England, particularly with respect to the more difficult and abstract sciences, we are not merely much below other nations of equal rank, but below several even of inferior power, . . . and nothing but the full expression of public opinion can remove the evils that chill the enthusiasm, and cramp the energies of the science of England."[1] Seventy years have passed since then, and though it cannot be said that the ground lost has been all regained, a vast change for the better has taken place. Public opinion has been awakened to the danger that threatens the country from this neglect.

It was long in vain that learned men, loving their

[1] *Quarterly Review*, xliii. 305, "Reflexions on the Decline of Science in England, and on some of its Causes."

country, and seeing where one source at least of its true greatness lay, called attention to our rulers' disregard of education and science. "The return of the sword to its scabbard" in 1815, says an author who wrote fifteen years later, "seems to have been the signal for one universal effort to recruit exhausted resources, to revive industry and civilisation, and to direct to their proper objects the genius and talent which war had either exhausted in its service or repressed in its desolations. In this rivalry of skill, England alone has hesitated to take a part." France was leading the way, and was making up the ground it had lost. "Let us frankly acknowledge the fact," Arago wrote, "at the time when Herschel was prosecuting his beautiful observations, there existed in France no instrument adapted for developing them; we had not even the means of verifying them. Fortunately for the scientific honour of our country, mathematical analysis is also a powerful instrument. Laplace gave ample proof of this on a memorable occasion, when from the retirement of his chamber he predicted, he minutely announced, what the excellent astronomer of Windsor would see with the largest telescopes which were ever constructed by the hand of man." And he adds, "It is for nations especially to bear in remembrance the ancient adage, *noblesse oblige!*"[1]

It was not and had not been an uncommon thing for kings and princes to encourage research, when George III. extended his patronage to the toiling musician of Bath. For two hundred years, at least, it had been a common thing in Europe—so common, indeed, that, if Herschel thought of it as a possibility

[1] Arago, *Biographies*, 223, 237.

in his own case, he was justified by what the world knew of the lives of men of science on the Continent. He could say, as Galileo said before him, "My private lectures and domestic pupils are a great hindrance and interruption to my studies; I wish to be entirely exempt from the former, and in great measure from the latter." Herschel had the same wishes, but not the same success, for Galileo was relieved of all professional duty, except giving lectures on extraordinary occasions to sovereign princes and other strangers of distinction. He was honoured with pensions and rewards from a petty prince in Italy, far superior at first to what Herschel enjoyed from the bounty of the wealthiest monarch and the richest country in the world.

Galileo was only one example out of a multitude. Leibnitz, the contemporary and rival of Newton, was another. He was laden with honours and rewards showered on him from one end of Europe to the other. He left "a fortune of sixty thousand crowns, which were found, after his death, accumulated in sacks in various kinds of specie." Descartes, Euler, the two Bernoullis, Huyghens, and many more are proofs of the encouragement given to science by kings and princes. But the example of Fraunhofer, the contemporary of Herschel, of Dollond, of Wollaston, first a common worker, then a great inventor and discoverer, shows best what George III. might have done for Herschel, and what Herschel was justly entitled to expect from a prince who was twofold his sovereign, as Elector of Hanover and King of Great Britain. Of Fraunhofer it is said "his own sovereign, Maximilian Joseph, was his earliest and his latest patron; and by

917154A

the liberality with which he conferred civil honours and pecuniary rewards on Joseph Fraunhofer, he has immortalised his own name and added a new lustre to the Bavarian crown." The German and other astronomers, who refused to accept *Georgium Sidus* as a name for the planet discovered by Herschel, were right, as things then stood: the King, who then did so shabbily by the astronomer, deserved neither part nor lot in the astronomer's heavens; and the common sense of mankind gave him none. But the King was unfairly judged, notwithstanding.

This encouragement of science stood on a different footing from the degradation of private patronage and fulsome dedications, to which literature had been subjected, and from which it had shaken itself free. But both literature and science were exposed to another danger than neglect—disparagement and envy from within their own borders. In the case of Herschel we have a curious example of what seems this meanness, written in 1830, eight years after his death: "Herschel's fame rests on discoveries, for which he was indebted solely to the great power of his telescope. That of the planet, sometimes called by his name, was an accidental discovery, in which genius had no part, and which could not have been much longer deferred. He did not, like his illustrious contemporaries Delambre and Piazzi, distinguish himself by the amelioration of the tables, or the reduction of catalogues of the stars, or by improving methods of computation, or indeed by any labour of practical utility. He devoted himself to the observation of astronomical phenomena, and in this department his unrivalled telescopes gave him a sort of supremacy.

His speculations concerning the structure of the universe—the progressive condensation of nebulæ and clusters of stars—the nature of the sun and the seasons of the planets—occupying a large portion of the goodly collection of sixty-seven Memoirs, which he contributed to the *Transactions of the Royal Society*—are lively and amusing, but they are entirely useless to astronomy, and have added nothing to the mass of real knowledge." What an ungenerous, narrow-minded, unjust criticism! Most certainly the man who, by patient effort and ingenious contrivance, advances the boundaries of human knowledge, if he is not a genius, deserves something better from his fellows than thus to be lightly esteemed for long-continued and successful labours. If Herschel had done nothing but invent a sounding-line to fathom the depths of space, and reveal worlds of light in countless profusion, he would have deserved well of humanity. The same criticism might have been passed on Galileo, who, in a letter to a friend, was proud to say that the Grand Duke "Ferdinand had been amusing himself with making object-glasses, and always carried one with him to work it wherever he went." Herschel, like Galileo and the Grand Duke, but on a vastly grander scale, was a grinder of mirrors for telescopes that were the wonder or envy of the world. And a distinguished man of science in our own time wrote of Herschel: "The success of this celebrated astronomer gave birth to a spirit of observation and inquiry which was before unknown. The heavens have been explored with the most unwearied assiduity, and this laudable zeal for the advancement of astronomy has been crowned with

the discovery of *four new planets*."[1] It was thus not only what Herschel was doing himself, but what he was inducing others to do.

George III. would not suffer William Herschel to return to his profession as organist, teacher of music, and director of concerts in Bath. He was in this guided by an impulse worthy of the King of a great commercial and earth-exploring country. But for more than two months Herschel was kept in London and the neighbourhood, waiting the King's pleasure. Double the time had elapsed during which he could be absent from duty without loss of money, but until he got leave from the King to return home he had to remain in attendance at Court. Whoever was advising His Majesty in the matter seems to have acted with singular want of thought. A Cosmo of Florence, a King of France, a Queen of Sweden, or an Empress of Russia would not have kept a man of science, who had at one bound sprung into greatness, dangling about the Court so long without providing for his personal wants. In Herschel's case it was otherwise, for he wrote to Bath "several times for a supply of money"! His friends in that city, loath to lose him, were, and not without cause, afraid that the offers made to him were not "very advantageous." They were certainly not creditable to those concerned. Herschel appears to have thought so himself, for, to all inquirers, but Dr. William Watson, his answer was, "that the King had provided for him."

It was a poor provision, even though no demands had been made on his time and strength. It was

[1] Sir David Brewster in his edition of Ferguson's *Astronomy*, published in 1823, the year after Herschel's death, ii. 85.

shabby when the return he had to make was set off against the salary he received. A teacher of elocution, the father of Richard Brinsley Sheridan, had enjoyed a pension of the same amount for about twenty years, through the influence of Lord Bute, "to enable him to carry on his literary pursuits."[1] But small though the allowance was, Herschel preferred the post of Royal Astronomer at Windsor to the troubles of a teacher's life at Bath. His friend Dr. Watson, not having yet forgotten, it may be, the discreditable civil war between "the sharps" and "the blunts," in which the King did not figure to advantage, four years before, only echoed what would have been the general sentiment of scientific men, had they known, as he did, the money part of the arrangement, when he exclaimed, "Never bought monarch honour so cheap!" It is far from pleasant to look back on this transaction or on the one-sided record of it given by Miss Herschel. Well would it have been had she laid the burden of blame on advisers, whom apparently she was not ignorant of. Probably it added to the bitterness which dropped from her pen, that in the following year, Pallas, or Mr. Pallas as he was called in this country, a student of George III.'s own University of Göttingen, and a man of science far from equal to Herschel, got *an addition* of £200 to his salary in Russia![2] For the transaction, as we have seen, had a shabbier look than appears on the surface. At least, as it is represented, so it seems. Herschel was to give lessons in astronomy to the Princesses of the Royal Family, when called upon, and to receive the visitors whom His Majesty might send. This might and did

[1] Watkins, *Memoirs*, etc., i. 104. [2] *Scots Mag.*, 1785, p. 536.

prove a tax upon him, especially if he had been up all night watching the heavens. Still, it seemed a leaf taken out of the book of duties laid on Galileo by Cosmo de Medici, and promised to be both a relaxation and a pleasure. The same cannot be said of the other part of Herschel's commission. He was at liberty and he was encouraged to make reflecting telescopes for sale, as a means of adding to his income. An arrangement so unwise, from the shopkeeping look it wore, should not have been proposed or sanctioned. It was a source of profit to the astronomer; but it did not differ from allowing Herschel to set up a factory for the manufacture and sale of telescopes with the Royal arms over the door, and "By appointment Royal Astronomer to the King" painted underneath. No one who reads the language in which Buonaparte wrote to Laplace not many years after, can be surprised that, in view of this lowering of science, England should have been spoken of by him as a nation of shopkeepers. The King himself became Herschel's first customer, ordering from him four 10-feet reflectors, one of which was intended as a present to the University of Göttingen, which had been founded by his grandfather, George II., forty-five years before, and was then rising into fame. These four reflectors cost six hundred and forty guineas apiece, and yielded a handsome profit.[1] Others, less costly, but still remunerative, were also ordered. Two hundred guineas

[1] This looks like the market price, if we may judge from Short's charges forty years before. "After Short had established himself in London in 1742 he received £630 for a 12-feet reflector from Lord Thomas Spencer. In 1752 he executed one for the King of Spain for £1200. The King of Denmark offered twelve hundred guineas" for

was a common price. To be an instrument-maker, and to sell telescopes, was allowed him by the King; but his sister's judgment on these conditions of the appointment is marked by her usual outspoken candour. Unfortunately, she presented the business in the least favourable light for the King, and her sentiments have been unfairly echoed to his discredit.[1]

Time so valuable as Herschel's was often absorbed by idle visitors, who understood little of his work, and made him no intellectual return. Sometimes a visit was paid to Slough that came to be remembered from its surroundings, but from nothing else. Of these none was more tragic than that of "the Princesse Lamballe, who came with a numerous attendance to see the moon, etc. About a fortnight after, her head was off."[2]

another (*Life of Newton*, i. 57). In Lalande's *Astronomy*, vol. i. xlix–lii, is a price-catalogue of astronomical instruments. Short's prices were—

12-inch	reflector,	14	guineas.
18	,,	20	,,
24	,,	35	,,
36	,,	75	,,
48	,,	100	,,
72	,,	300	,,
144	,,	800	,,

Only one telescope of 12 feet was made by Short. In presenting a 10-feet reflector to the Society at Göttingen, George III. was following the example of his grandfather, the founder of the University, who presented it in 1756 with a mural quadrant of 6-feet radius, made by Bird (£175), and other instruments.

[1] Sir David Brewster goes too far on the other side when he says, "None of the sovereigns who either preceded or followed him have an equal claim on the homage of astronomers" (*Life of Newton*, i. 60). This could not be said of the King at first.

[2] *Memoirs*, p. 332. This is assigned to 1787, when she was certainly in England; but the Princess perished in 1792.

CHAPTER VII

THE GREAT TELESCOPE

THERE is reason to believe that the discoverer of the telescope was Roger Bacon, who in the thirteenth century also invented gunpowder, and was rewarded with the curses of the Church, the reproaches of his fellow-friars, and the terror of the ignorant as a wonder-worker by the aid of evil arts. His discovery of how to see to a greater distance than the eye can reach, was a seed that died in the ground, and did not come to life again till the world was more than three centuries older. A spectacle-maker of Leyden, Lippershey, working among lenses, as the glasses of spectacles are called, chanced to place two of them so that, in looking through, he saw a distant church spire as if it were close at hand. He made the story public in 1609. Galileo, who happened to be then in Venice, between which and Holland the East India traffic still continued, and gave rise to a considerable commerce, heard the story, probably from some merchant, and, instead of turning it into ridicule as many would have done, set himself to find out if he could not do what a humble spectacle-maker on the other side of Europe had already done. He was successful. He brought the moon and the planets so much nearer to the earth that astronomy took its place among the sciences.

Professors, monks, and friars were as bitter revilers of Galileo as they had been of Roger Bacon. The sleep of ages of ignorance was so rudely broken by the magical little tube he put together, that, as they rubbed their eyes and saw the old world of thought dissolving out of view, they cursed the disturber of their graveyard peace.

Galileo's first telescope magnified three diameters or nine times: his last magnified thirty-three diameters. He could not go farther with the glass lenses then in use. At thirty-eight diameters the colours, developed in the passage of rays of light through glass, or by what is called refraction, put an effectual stop to progress. Newton began where Galileo stopped. He analysed a beam of sunlight into its component colours as they are seen in the rainbow, or through a glass prism. He came to the conclusion that "refraction could not be produced without colour." He was mistaken, and the mistake of a man so eminent led the whole world astray. Acting on this belief, he argued that "no improvement could be expected from the refracting telescope," that is, from an instrument with a glass or lens at the object end of the tube to form an eye that collected and focused the rays of light. Colour, though thus barring the march of advancing science, really indicated the path of progress. But nearly two centuries elapsed before the lost road was regained, and the prism of glass became a more powerful factor in revealing the wonders of distant worlds than the best telescopes. However, progress was not wholly barred. Colours were not developed by the reflection of light from a polished surface. If, then, a highly polished mirror were placed in the bottom of a

tube, open at the other end, the rays of light could be brought to a focus and directed to an eye-piece, where an observer, with his back to the object, it might be, could see it clearly and distinctly magnified. The mirror required to be of a parabolic form, and might be made of metal or of glass. Newton chose an alloy of tin and copper for the mirror or speculum, but he did not trouble himself about grinding it into the form of a parabola. The second reflecting telescope he made magnified thirty-eight diameters, and was presented to the Royal Society in 1671. Half a century passed before any farther step was taken with either refracting or reflecting telescope. Hadley, the inventor of the sextant, then took the matter up. In 1723 he made one on Newton's pattern, with a mirror of 6 inches aperture, and a focal length of 62⅝ inches. Its eye-pieces magnified up to 230 diameters. A report on it was made to the Royal Society, of which the substance was that Newton's telescope "had lain neglected these fifty years," but Hadley had shown "that this noble invention does not consist in bare theory." Strange to say, in that very year an English gentleman had made a refracting telescope, which largely overcame the difficulties arising from colour. His was the first achromatic or colourless telescope: it remained the only one for another fifty years. Although its inventor lived all that time, he neither claimed first honours nor interfered with the patent of the second discoverer, Dollond.

Another half-century thus passed, and little or nothing had been done. Dollond had rediscovered in 1758 the method of counteracting colour in glass lenses, but no one seemed disposed to apply the prin-

ciple on a large scale. Apparently the way here also was barred against progress. All attempts to manufacture discs of pure flint glass larger than seven inches in diameter failed. Up to that point the achromatic refracting telescope was a great success. For seventy years good specimens of considerable size were exceedingly rare, and even in 1830 a disc of eleven inches and seven-tenths in diameter cost £1000.[1] An obscure musician, considering it probably impracticable to extend the range of Dollond's telescope, or impressed by the name and authority of Newton, was amusing himself, in 1772, if hard and continuous work can be called amusement, with casting and grinding mirrors, with mounting telescopes, and with studying the heavens in Bath, the gayest and idlest city in England. The people who formed the Literary Society of the town, who met to read papers on scientific subjects, and some of whom were members of the Royal Society of London, did not even know him. They were pigmies; a giant was among them, of whose existence and works they were not aware.

The courage of this musician was extraordinary. In the very year in which he removed to Bath, Messier, an eminent French astronomer, warned the Royal Society of London that progress in astronomy could be hoped for only from refractors. His words are: "It were to be wished that astronomers might be accommodated with achromatic telescopes of the most perfect construction, as such are the only instruments whereby a great knowledge of the celestial bodies can

[1] Herschel sometimes used a 3½-feet achromatic or refracting telescope and a single eye-lens to confirm apparently the evidence of his 20-feet or 7-feet reflectors.

be acquired." Herschel cannot well be supposed to have been ignorant of this scientific faith. With the modest boldness of true genius he not only set it aside, but he proved it was entirely wrong. This was at the very beginning of his career. A novice challenged the accuracy of an eminent master and veteran in the art! A novice compelling a veteran to withdraw his prophecies and confess himself in error! Why he thus set aside the refractor and boldly followed to unimagined ends the path of improvement for Newton's reflector he has not told us. Both ways were open; he had perhaps tried both, for he was aware of both; but he preferred the latter.

While still engaged as musical director and teacher at Bath, Herschel formed the design of constructing a 30-feet reflector with a 3-feet mirror. This was about the year 1778, before he was even known to the upper classes of citizens or visitors as an amateur astronomer. The first mirror of this kind which he cast cracked in the cooling. When preparing for a second casting, the furnace, which he had built on purpose in his own house, gave way, the molten metal ran into the fire, overflowed the stone floor, and nearly cost him his life. But his papers in the *Philosophical Transactions* were making him known, and his discovery of the planet Uranus brought him to the King's notice, and put a stop for a time to the realisation of his cherished idea of a great telescope. From the first he was bent on doing what no other had done before him—carrying out Newton's conception of a great reflector, whether the mirror used were glass or metal, and exploring the heavens with an instrument such as the mind of man had never before imagined.

He conceived the idea of a 40-feet reflector, with a 4-feet mirror at the bottom of the tube, cast and polished by himself. His own account of the beginning of this magnificent work is this: "In the year 1783 I finished a very good 20-feet reflector with a large aperture, and mounted it upon the plan of my present telescope. After two years' observation with it, the great advantage of such apertures appeared so clearly to me, that I recurred to my former intention of increasing them still farther; and being now sufficiently provided with experience in the work I wished to undertake, the President of our Royal Society, who is always ready to promote useful undertakings, had the goodness to lay my design before the King. His Majesty was graciously pleased to approve of it, and with his usual liberality to support it with his Royal bounty." There is this to be said on the departure now made, that the great telescope, from the difficulty of handling it, cannot be considered to have altogether answered his expectations, for the 20-feet continued to be his favourite in studying the heavens. But he was full of hope. "By applying ourselves," he wrote in April 1784, "with all our powers to the improvement of telescopes, which I look upon as yet in their infant state, and turning them with assiduity to the study of the heavens, we shall in time obtain some faint knowledge of, and perhaps be able partly to delineate, *The Interior Construction of the Universe.*"

Herschel himself devised and superintended everything about this great telescope. None but "common workmen" were employed, as was also the case with the greater reflector built by Lord Rosse, sixty years later. The woodwork of the stand, and machines for

giving the required motions up or down, right or left, were designed, drawn, and overlooked by him in their minutest details. Not a screw bolt was put in—and nothing else was used to obviate the effects of damp getting a lodgment in the woodwork—without his own eye watching or directing the work. The casting of the great mirror was begun while the building of the stand was thus proceeding. He had to remove from Datchet to Clay Hall, and thence, in 1786, to Slough, before the mirror was finished, but apparatus and materials were all transferred from the one house to the other without delaying the work. So rapidly had the work been pushed forward that the stand was ready, and the mirror, "highly polished," was put in the tube in less than a year and a half. "I had the first view through it," Herschel writes, "on Feb. 19, 1787." It was not satisfactory. "By a mismanagement of the person who cast it, it came out thinner on the centre of the back than was intended, and on account of its weakness would not permit a good figure to be given to it." Twelve or fourteen men had been daily employed in grinding or polishing it by hand, for machinery did not come into use for this purpose till 1788. It was labour lost. The work had to be begun anew, and a second mirror was cast Jan. 26, 1788, nearly a twelvemonth after the first peep into the other. Fatality again! "It cracked in cooling." Three weeks after it was recast, and by Oct. 24 it was brought to such "a figure and polish" that he tried it on the planet Saturn. He was so dissatisfied with the result that he "continued to work upon it till Aug. 27, 1789, when it was tried upon the fixed stars, and found to give a pretty sharp image,"

although "large stars were a little affected with scattered light, owing to many remaining scratches in the mirror."

Four years of hard thinking and continuous labour, of battles with not very intelligent workmen, sometimes forty in number, and of disappointment with himself, if not also with grumbling from his sister Caroline, ended at last. A triumphant tone may be heard in the words which conclude his short history of the progress of the work. They are:—

"Aug. the 28th, 1789.—Having brought the telescope to the parallel of Saturn, I discovered a sixth satellite of that planet, and also saw the spots upon Saturn better than I had ever seen them before, so that I may date the finishing of the 40-feet telescope from that time."

Herschel could now take stock of the "contents of the heavens" as he had never been able to do before. High above the ground, while the tube was coated with ice in winter, or running with streams of moisture in summer, he could dictate through speaking-tubes what his sister was to write down, or how the assistant was to move the telescope. Seated in a little house far below, his sister watched the clock, and entered remarks and measurements with an accuracy and zeal no other assistant could have equalled or surpassed. Brother and sister were in a position to carry out great ideas, and to put into living shape vast imaginations of genius.

The cost of this telescope was far more than Herschel could be expected to meet. Fortunately, the advisers of the King were more reasonable men than those who considered £200 a year remuneration enough

for the Royal Astronomer. Chief among them was the Mæcenas of science in those days, Sir Joseph Banks, the companion of Cook, and the President of the Royal Society. Owing to his representations, the King allowed his astronomer £2000 for the construction of the telescope, and afterwards £2000 more to complete it, with £200 a year for necessary repairs, painting, ropes, etc., and men's wages, and £50 a year of pension for Caroline. When Caroline Herschel records these handsome allowances from the King, she expresses no thankfulness, though her own personal expenses for seven years previous had not amounted to more than £8 a year! But she had cause to complain. "I never felt satisfied," she writes in 1827, "with the support your father received towards his undertakings, and far less with the ungracious manner in which it was granted. For the last sum came with a message that more must never be asked for." One of the requests was a small salary for her as assistant to her brother. The sum granted was £50 a year. For nine quarters it was left unpaid! It is perhaps matter of regret that she wrote as she did of the shabbiness of the pension allowed to her brother. She did the King a grave injustice. And she forgot, besides, that while the King paid £4000 for the telescope,[1] and allowed £200 a year for upkeep and wages, the instrument remained her brother's private property. William Herschel shows no trace of the grumbling, cynical spirit of his sister. He knew how handsomely he had been treated. At the same time there is a most amusing raciness about her view

[1] Letter from Sir John Herschel, March 13, 1847: Weld's *History of the Royal Society*, ii. 193.

of the building of this grand instrument, which it would be a mistake to overlook.

Caroline Herschel had difficulties with servants from her earliest days of housekeeping. No one pleased her; whether because, having been intended for a household drudge herself by her mother and her brother Jacob, she was too exacting when it came to her turn to lord it over others, or from the ignorance and disregard to right of the class servants were drawn from, we cannot tell. But her account of the workmen whom her brother employed on the great telescope paints the employed of those days in colours more black, and more incredible, than we are warranted in receiving without scruple. For some weeks in the summer of 1786 she was left in charge at Slough, while her brother was absent in Hanover on a scientific mission from the King, charged in fact with conveying to the University of Göttingen a 10-feet reflector, constructed by Herschel, and presented by the King for the Observatory, which had already taken high rank in Europe. "There were no less than thirty or forty of my brother's workpeople," she writes, "at work for upwards of three months together, some employed in felling and rooting out trees, some digging and preparing the ground for the bricklayers who were laying the foundation for the telescope, and the carpenter in Slough, with all his men. The smith, meanwhile, was converting a washhouse into a forge, and manufacturing complete sets of tools for the work he was to enter on. . . . In short, the place was a complete workshop for making optical instruments, and it was a pleasure to go into it to see how attentively the men listened to and executed their master's orders."

This is one and a pleasingly picturesque side of the medal, that might have been struck to commemorate the building of the great reflector. But another and an almost incredible other side is presented on the same page of her *Memoirs*. "I cannot leave this subject," she says, "without regretting, even twenty years after, that so much labour and expense should have been thrown away on a swarm of pilfering work-people, both men and women, with which Slough, I believe, was particularly infested. For at last everything that could be carried away was gone, and nothing but rubbish left. Even tables for the use of work-rooms vanished: one in particular I remember, the drawer of which was filled with slips of experiments made on the rays of light and heat, was lost out of the room in which the women had been ironing. . . . It required my utmost exertion to rescue the manuscripts in hand from destruction by falling into unhallowed hands or being devoured by mice." A nest of savage South Sea islanders, lifting whatever they could carry away from a house within two or three miles of Windsor Castle in the end of last century may be an accurate picture of the ways and manners of English workpeople then, but it is pardonable to receive it with a smile of incredulity, and to imagine other reasons for the alleged pilfering.

Servants seem to have been a cross which Caroline Herschel never could bear with an equal mind. In 1831, when she was eighty-one, she was as hard to satisfy as in 1772, when she was only twenty-two: "The first thing my radical servant did when she came to me was to break the bottle containing the ink of my

own making, which was to have lasted me all my lifetime."[1]

The ingenuity of the appliances for ensuring stability and lightening labour in consulting the telescope was a monument to the mechanical genius of Herschel, in keeping with the greatness of the mirror. These appliances are now things of the past, not to be repeated by any future adventurer in the fields of research, but none the less worthy of respectful regard even in this age of engineers. They were not successful in making a cumbrous machine so light and easy to handle as science required, but that is only saying that the necessity for this preceded the discovery of the means of doing it, and that the first attempts were inferior to those made later. The iron tube, at the bottom of which lay the colossal eye that looked heavenwards, was 39 feet 4 inches in length and 4 feet 10 inches in diameter. It was an unwieldy and far from necessary addition to the structure, enough to cause error in observations by its ton-weight and instability. He had also to make arrangements for conveying observers and visitors from the ground to the gallery, 30 feet high or more, to whom ladders would have been difficult or dangerous. A chair-lift was devised, but was never erected. So easy did he find the ladders, and such was his agility at sixty and seventy years of age, that he preferred to reach or leave his post of observation by running up or down them. Among other requirements was a means of communicating readily and at once from his lofty perch both with the recorder of observations, whose

[1] March 1831, *Memoirs*, p. 244. Compare this with the "hot-headed old Welshwoman" of 1772, p. 33.

duty was, under cover of a roof, to watch the clock, and to enter the measurements or remarks of the observer, as well as with the workman in attendance. A "speaking-pipe," as it was then called, of variable length to suit changes in his position, but 115 feet long at the most, was devised and fitted up. Usually his sister Caroline was the recorder who did the work, all-night work at times.

The mechanical skill shown in the construction of the telescope was proved sixty years after by Herschel's distinguished son, Sir John, in a letter already referred to, dated March 13, 1847: "The woodwork of the telescope being so far decayed as to be dangerous, in the year 1839, I pulled it down (the operation commenced on December 5), and having cleared away the framework, etc., piers were erected on which the tube was placed, *that* being of iron, and so well preserved, that although not more than one-twentieth of an inch thick, when in the horizontal position it sustained within it all my family, and continues to sustain enclosed within it to this day, not only the heavier of the two reflectors, but also all the more important portions of the machinery, such as being of iron and brass stood in no fear of decay, as well as all such portions of the polishing apparatus as would go into it, to the amount, I presume, of a great many tons, which had, when I last saw it, produced no sign of weakness or sagging down. This great strength and resistance to decay is to be attributed to the peculiar principle of its internal structure, which is, in effect, very similar to that for which, in later times, a patent has been taken out under the name of *Corrugated Iron Roofing*, etc., but of which the idea was, I

have every reason to believe, original with my father at the time of its construction; as was, I am disposed to think, also the *system of triangular arrangement* adopted in the woodwork, being a perfect system of 'diagonal bracing,' or rather that principle to which the 'diagonal bracing' system owes its strength.

"The other mirror and the rest of the polishing apparatus are on the premises, but in a situation adapted only for preservation, and neither for use nor inspection. The iron grinding tools and polishers are placed underneath the tube, let into the ground, and level with the surface of the gravelled area in which it stands." [1]

The duty of attending to machinery and mirrors, in an observatory such as Herschel's, was not free from danger. Even visitors had to take the risk of an accident in satisfying their curiosity. Piazzi of Palermo, the discoverer of the first asteroid, "did not go home without getting broken shins," Caroline writes. And she adds, "I could give a pretty long list of accidents which were near proving fatal to my brother as well as myself." [2] One of these accidents she does record. It was on December 31, 1783: "The evening had been cloudy, but about ten o'clock a few stars became visible, and in the greatest hurry all was got ready for observing. My brother, at the front of the telescope, directed me to make some alteration in the lateral motion, which was done by machinery, on which the point of support of the tube and mirror rested. At each end of the machine or trough was an iron hook,

[1] Weld, *History*, etc., ii. 193.

[2] See especially, *Memoirs*, p. 168.

such as butchers use for hanging their joints upon, and having to run in the dark on ground covered a foot deep with melting snow, I fell on one of these hooks, which entered my right leg above the knee. My brother's call, 'Make haste!' I could only answer by a pitiful cry, 'I am hooked!' He and the workmen were instantly with me, but they could not lift me without leaving two ounces of my flesh behind. . . . At the end of six weeks I began to have some fears about my poor limb. . . . I had, however, the comfort to know that my brother was no loser through this accident, for the remainder of the night was cloudy." The compensation she urges, in extenuation of the accident, by its drollery almost makes us forget its gravity. Once also when her "brother was elevated fifteen feet or more on a temporary cross-beam instead of a safe gallery," a very high wind so shook the apparatus that "he had hardly touched the ground before the whole of it came down." If accidents so serious happened before the heavier and more cumbrous machinery of the 40-feet telescope was erected, we may be certain that Herschel's mechanical skill did not avail to prevent them in the working of the great telescope.

If Herschel had done nothing more for science than build this great telescope he would have amply earned the high eulogium graven on his tombstone at Upton, "The barriers of the heavens he broke through, penetrating as well as exploring their more remote spaces." Nothing to compare with it had been seen before. It was a wonder that the gravest man of science regarded with deepest admiration, and children at school looked on with awe in the pictures of it seen on the pages of

books they read. But the spirit of a wholesome rivalry, which it awoke in many bosoms, did more for astronomy than its builder or it ever did. It was the origin of other instruments of the same kind, as grand as itself or even grander. Some men of science, waspishly inclined perhaps, denounced the great telescope as of no use. Both in England and on the Continent this was said, and most unfairly, as everyone who reads Herschel's papers may discover for himself. He has frankly and fully explained in his writings[1] why he preferred to use other and smaller telescopes, and perhaps to use them oftener, but his love for and his pride in this work of his hands is ever and again coming to the front. One instance alone deserves to be quoted as a specimen: "I saw the fourth satellite and the ring of Saturn in the 40-feet speculum without an eye-glass."[2]

But it was seldom that astronomers on the Continent followed the example of William Herschel or gave themselves the trouble he took. Some of them did. Of "Professor Amici, an artist and a man of science of the first rank," his son, Sir John Herschel, writes: "He is the only man who has, since my father, bestowed great pains on the construction of specula, and his 10-foot telescopes with 12-inch mirrors are of very extraordinary perfection." This was true at the time it was written, two years after his father's death. It did not remain true, for Lord Rosse's great 6-feet mirror and 56-feet tube had still to come. And like Herschel, Lord Rosse was his own workman. When visiting him at Birr Castle in 1862,

[1] *Phil. Trans.*, 1815, p. 295.
[2] *Phil. Trans.*, 1791, p. 76 (October 10).

Nassau Senior relates that "the smaller speculum of the great telescope had been broken, and no one except Lord Rosse himself could polish it, which he had not yet had time to do; but we have been able to use the 3-feet reflector."[1] The necessity of this personal labour from the owner himself, hard manual labour, was one great drawback to the value of these magnificent instruments.

Kings and princes and men of science paid handsome sums to Herschel for telescopes made by his own hand. While the great telescope was in progress, George III. presented the Observatory of Göttingen with a reflector, which Herschel took to Hanover along with his brother. He also ordered other 10-feet for himself, and many 7-feet besides had been bespoke; but the finest and costliest was one for the King of Spain, ordered in 1796 and not sent off till October 1801. It cost £3150. Other two for the Prince of Canino brought £2310. But this was telescope-selling, not star-observing. It cost time and trouble, that might have been devoted to better purpose. No wonder that his sister grumbled. She was hindered in her proper work by the packing of the Spanish reflector, "which was done at the barn and rickyard at Upton, her room being all the while filled with the optical apparatus."[2] It was small satisfaction to her that the University of Edinburgh conferred the degree of LL.D. on her brother in 1786. She did not consider that reward at all equal to his merits. She echoed the words of General Komarzewski, spoken by him probably in fun, but received by her in earnest, that Herschel should be honoured as the Duke of

[1] *Journals, etc., relating to Ireland*, ii. 247.
[2] *Memoirs*, p. 110.

Slough. He did not even get a knighthood from his Royal patron. In 1816 he was made a Hanoverian Knight by the Prince Regent; traders, slave-holders, moneyed men of all classes were raised to the peerage, but brain power was then less esteemed for the bestowal of worldly rank.

Before the tube was fitted with the great mirror, many of the visitors who flocked to see William Herschel had the curiosity to walk through it. Among them was the King. Close behind him was the Archbishop of Canterbury, who found it difficult to proceed, till the King turned to give him his hand, saying, "Come, my Lord Bishop, I will show you the way to heaven."

An invitation from Mr. Herschel to walk through the tube, as it lay on the ground, was not uncommon. Miss Burney and the party she was with accepted the invitation. "It held me quite upright," she says, "and without the least inconvenience; so would it have done had I been dressed in feathers and a bell hoop—such is its circumference. Mr. Smelt led the way, walking also upright; and my father followed. After we were gone, the Bishop [of Worcester] and Dr. Douglas were tempted, for its oddity, to make the same promenade."[1] Evidently the Church was not disposed, in those days at least, to look Heaven in the face.

While the greater tube of Lord Rosse's telescope was lying in readiness to receive its greater mirror, visitors were also in the habit of walking through it, sixty years later. The Dean of Ely, a well-known mathematician, and a man of more than the common

[1] *Letters*, iii. 262.

height, is said to have walked through with his umbrella up. The days of these gigantic tubes are past. The career of Herschel's 40-feet was inaugurated by a concert held within the tube, just as its end was celebrated half a century afterwards. "'God save the King' was sung in it by the whole company, who got up from dinner, and went into the tube, among the rest two Misses Stow, the one a famous pianoforte player, some of the Griesbachs, who accompanied on the oboe, or any instrument they could get hold of, and I," Caroline in her ninetieth year continues, "you will easily imagine, was one of the nimblest and foremost to get in and out of the tube. But now!—lack-a-day!—I can hardly cross the room without help." She was then a giddy girl of only thirty-seven! But when the concert was held in the tube at the end of the great telescope's career, she was in Hanover, never destined again to see the noble work of her "best and dearest of brothers."

On the return of Sir John Herschel from South Africa in 1838, it was found that the woodwork of the great telescope was so decayed that the structure was dangerous. It had stood exposed to wind and weather for more than fifty years, and the discovery of its unsafe condition was made on the centenary of the builder's birth. In the following year it was taken down, and on New Year's Eve[1] a meeting of the Herschel family was held within the iron tube, then lowered on the ground, to celebrate the end of the instrument. Sir John's ballad was sung that night, and is now preserved as a printed broadside among

[1] Said in the *Memoirs* to have been at Christmas (p. 310). Different in Arago, *Biographies*, 171.

other relics of a famous past in the Royal Observatory at Greenwich.

The Herschelian Telescope Song[1]

Requiem of the Forty-feet Reflector at Slough, to be sung on the New Year's Eve, 1839–40, by Papa, Mama, Madame, and all the Little Bodies in the tube thereof assembled :—

In the old Telescope's tube we sit,
And the shades of the past around us flit;
His requiem sing we, with shout and with din,
While the old year goes out and the new one comes in.

Chorus of Youths and Virgins.

Merrily, merrily, let us all sing,
And make the old Telescope rattle and ring.

Full fifty years did he laugh at the storm,
And the blast could not shake his majestic form;
Now prone he lies where he once stood high,
And searched the deep heavens with his broad bright eye.
Merrily, merrily, &c.

There are wonders no living wight hath seen,
Which within this hollow have pictured been;
Which mortal record can ne'er recall,
And are known to Him only who makes them all.
Merrily, merrily, &c.

Here watched our father the wintry Night,
And his gaze hath been fed with pre-Adamite light;
While planets above him in mystic[2] dance
Sent down on his toils a propitious glance.
Merrily, merrily, &c.

---

[1] Weld, *History of the Royal Society*, ii. 195.
[2] ? circular.

He has stretched him quietly down at length,
To bask in the starlight his giant strength;
And Time shall here a tough[1] morsel find,
For his steel-devouring teeth to grind.
Merrily, merrily, &c.

He will grind it at last, as grind it he must,
And its brass and its iron shall be clay and dust;
But scathless ages[2] shall roll away,
And nurture its frame in its form's decay.
Merrily, merrily, &c.

A new year dawns and the old year's past,
God send us a happy one like the last,
A little more sun and a little less rain,
To save us from cough and rheumatic pain.
Merrily, merrily, &c.

God grant that its end this group may find
In love and in harmony fondly joined;
And that some of us fifty years hence, once more,
May make the old Telescope's echoes roar.

Chorus, fortissimo.

Merrily, merrily, let us all sing,
And make the old Telescope rattle and ring.

Where the great telescope raised its eye heavenward, a church has been built to direct men's thoughts to do what brother and sister long did in loving fellowship, "mind the heavens." It was a fitting consecration of the hallowed ground. In speaking of his magnificent work in 1813, Herschel said to Thomas Campbell the poet, "with an air, not of the least pride, but with a greatness and simplicity of expression that struck me with wonder, 'I have looked farther into

[1] ? rough. [2] ? rays.

space than ever human being did before me. I have observed stars, of which the light takes *two millions* of years to travel to this globe.'" The Church is a telescope that looks, or should look, even farther into space and time.

While Herschel was giving life and power to the reflecting telescope, Dollond's followers in this country and Fraunhofer in Germany were restoring the refractor to the place from which it had been deposed. In 1825 the finest refractor that, up to that time, the world had ever seen was erected for Struve at the expense of the Russian Government in Dorpat. The tube was 13 feet in length, and the object-glass was 9 Paris inches in diameter. The weight of the whole was about 3000 Russian pounds. Of his first look through it Struve says: "I stood astonished before this beautiful instrument, undetermined which to admire most, the beauty and elegance of the workmanship in its most minute parts, the propriety of its construction, the ingenious mechanism for moving it, or the incomparable optical power of the telescope, and the precision with which objects are defined."[1] He was proud of his assistant. He believed it to be the equal of Herschel's 40-feet reflector, and it was certainly far more easy to work. With its help he continued the work Herschel began. It appears, however, that Herschel sometimes used a parabolical glass mirror of 7-feet focal length instead of the metal mirror,[2] avoiding by reflection the colours due to refraction. This should be remembered to his credit.

[1] *Astronom. Trans.* ii. 94. [2] *Phil. Trans.* for 1803, p. 228.

CHAPTER VIII

"THE CONSTRUCTION OF THE HEAVENS"[1]

THE writer who described Herschel's papers as "lively and amusing" may have intended a sneer, but he did a great wrong to inquiries and facts as novel as they were inspiring. Whatever helps to lift man's thoughts above the littlenesses of life and time is a distinct gain to the human race, altogether irrespective of the uses to which, in course of time, it may be applied. Herschel's papers on *The Construction of the Heavens* were of this nature. They were among the first he wrote; they were also among the last. He wrote at least eight papers on the subject, covering three hundred and thirty quarto pages: he began the series in 1784, he finished it in 1818, and he left the work as a legacy to his son, who nobly honoured his father's memory by doing for the southern hemisphere what the father did for the northern. Even though these labours had been nothing more than an attempt on man's part to penetrate the workshop of

[1] This is Herschel's own phrase, taken probably from the notice of Ptolemy's *Almagest* (145 A.D.) in Lalande's *Astronomy* (1771 A.D.), where its title is given in Latin, *Magna Constructio* (i. 156). The phrase does not deserve the condemnation it received from an Edinburgh Reviewer in January 1803; but a later Reviewer accepts it in July 1848, "to use a phrase which Sir W. Herschel introduced" (p. 105). "Introduced" is scarcely correct.

nature and ascertain the hidden processes of an Almighty Worker, they would have been invaluable as a serviceable hypothesis for future efforts. Boldly and with all reverence, he set himself to open the closed hand of Almighty Wisdom, and find what that Power had kept hid. Others laboured in this cause before him, but "we are indebted solely to the genius and industry of Dr. Herschel for perfecting their sagacious views, and supporting them by a body of evidence amounting nearly to demonstration."[1]

The first point he laid down was that there is ample reason "strongly to suspect that there is not, in strictness of speaking, one *fixed* star in the heavens." Fixed stars is a name we have been led to use, because, unlike the planets or wanderers, they seem never to change their places in the sky; but absolute rest in any one of these stars is impossible except, it may be, as a result of nicely balanced forces. Herschel was beginning in 1783 A.D. at the same starting-point as the famous Hipparchus nearly two thousand years before, who "observed a new star which appeared in his own day, and which led him to believe that the same thing might happen frequently, and that the stars considered fixed might be in motion."[2] The proper motion, as it is called, of some of the brightest stars was suspected nearly a century before Herschel's time and was afterwards fully proved. What the nature of that motion may be, might be guessed by astronomers, but was really

[1] Sir David Brewster in his edition of Ferguson's *Astronomy* (1823), ii. 298. He is referring specially to nebulæ, of which Herschel "observed the position, magnitude, and structure of no fewer than 2500."

[2] Lalande, i. 152; Pliny, ii. 26.

a fruitful field for genius and perseverance to cultivate. "Its causes and laws are hid for the present in almost equal obscurity," was the judgment of Dr. Maskelyne, then Astronomer-Royal; but it pointed to changes among the stars, which a shrewd observer would endeavour to ascertain and account for. Herschel undertook the work. Availing himself of a catalogue of 2884 stars published in 1723 by Flamsteed, the first Astronomer-Royal, he compared the heavens of his own day with the appearance they presented then. He had no star charts such as astronomers have since constructed, and which, when compared with a revised edition a century hence, may reveal much that is at present dark regarding the motions and destiny of the small but beautiful home of our shortlived race. He had no photographic plates to expose or consult. From beginning to end it was eye-labour and hand-labour with this intrepid traveller among these far-away suns. So laborious was the comparison that he had "many a night, in the course of eleven or twelve hours of observation, carefully and singly examined not less than 400 celestial objects, besides taking measures of angles and positions of some of them with proper micrometers, and sometimes viewing a particular star for half an hour together, with all the various powers of his telescope." During that interval of sixty years he found that stars had been lost or had vanished, that they had undergone some capital change of position or magnitude, or had come into sight where they were not previously seen, although "it is not easy to prove a star to be newly come" into any part of the sky. If a star suddenly shone out so as to attract the eyes

of the common people, where a practised observer was sure there was no star visible an hour or two before, was he to conclude that it had flared up as if it were on fire, and that it would go out as the fire died down? Or, if he saw a star brightening, paling, going out, and brightening again every three or four days, or weeks or months, or every three or four years, was he to infer that dark bodies of vast size were thrusting themselves between that distant sun and our eyes, eclipsing it, in fact; or that immense reaches of unlighted space, or dark regions on its surface, were turned for a time towards us, as it revolved on its axis? Dark spots on a sunny star's surface and a rotation more or less rapid were the causes accepted by Herschel from previous astronomers for this change of brightness in what are called changing or variable stars. He examined seven that were then known. Their periods were 3, 5, 6, 7, 331, 394, and 497 days.[1] He felt, however, that his views were discredited by the sudden bound from 7 days to 331. Unless a star were found bridging the gulf between these two, he would not have had confidence to give his theory to the world. But the star α Herculis seemed to him to bridge the gap, and satisfy the theory. Its period was found to be about 60 days. These and other changes on the face of the heavens, known for many years and registered in books, formed Herschel's prelude to the work he had set his heart on, *The Construction of the Heavens*. That they are a building, a wonderful temple consecrated to Almighty Power and Wisdom, he never doubted. To discover the plan

[1] *Phil. Trans.* (1796), pp. 455–56. Professor Holden gives the numbers as 3, 5, 6, 7, 334, 404, and 494 (p. 133).

on which the All-wise Worker proceeded was his aim and ambition.

Stars had been seen by Flamsteed which Herschel could no longer find. A century had elapsed, and Herschel put these stars down as "lost." He meant that a star thus noted was not to be seen when he looked for it, "but that possibly at some future time, if it be a changeable or periodical star, it may come to be visible again." In other cases he entered in his journal the remark, "Does not exist," when Flamsteed had not himself seen the star. Herschel, however, does not appear to have considered that these "lost stars" may have been comets, or wanderers like his own Uranus, or specks like the numerous body of asteroids and satellites, that were then undiscovered. In a paper written at a later period he found that he had treated as faultless a catalogue of stars which required correction. His conclusions regarding lost or changing stars were thus premature. But neither the poetic beauty nor the possibility of a "lost" star can be denied. Perhaps he was only borrowing a phrase that was used nearly two thousand years earlier by Hipparchus, who, by his catalogue of the fixed stars, gave future generations the means of ascertaining "if stars could be lost and reappear, if they changed their place, their size, their brightness."

Dissatisfied with the principles on which stars visible to the naked eye are classed, according to their brightness, as stars of the first, or second down to the sixth magnitude, he began, about 1782, to adopt a new and more effective but certainly a very laborious method of settling degrees of brightness among the stars, and of determining to what extent

the brightness changed from year to year, or from age to age. By this method actual inspection would at once decide whether a star was increasing or diminishing in brightness compared with other stars. It was an attempt to ascertain the advance of life or the vigour of youth, the beginnings of decay or the promise of a long continuance of brightness among the countless suns in creation. Of the importance of these investigations he entertained no doubt, nor should we. "The great number of alterations of stars that we are certain have happened within the last two centuries, and the much greater number that we have reason to suspect to have taken place," are curious features in the history of the heavens, as curious as the slow wearing away of the landmarks of our earth on mountains, on river banks, on ocean shores. "If we consider how little attention has formerly been paid to this subject," he goes on to say, "and that most of the observations we have are of a very late date, it would perhaps not appear extraordinary were we to admit the number of alterations, that have probably happened to different stars, to be a hundred; this compared with the number of stars that have been examined, with a view to ascertain their changes, which we can hardly rate at three thousand,[1] will give us a proportion of 1 to

[1] The most ancient catalogue of the stars is that of Ptolemy (140 A.D.) of Alexandria, which was probably a revised transcript of that of Hipparchus (160 B.C.). It contains 1022 stars. Tycho's catalogue (1572 A.D.) contains 777 principal stars, to which Kepler afterwards added 280, taken probably from Tycho's own manuscripts. Hevelius (1690 A.D.) published a catalogue containing 950 stars of former lists, 603 observed by himself, and 377 southern stars observed by Halley from Saint Helena. "But the most perfect and the largest catalogue

30 . . . even 1 to 300 is sufficiently striking to draw our attention." These were the words of a wise observer, uttered long before geologists had begun to use similar language in their own researches.

The conclusion which Herschel drew from these alterations, real or imagined, in the light of the stars was that they will "much lessen the confidence we have hitherto placed upon the permanency of the equal emission of light of our sun. Many phenomena in natural history seem to point out some past changes in our climates. Perhaps the easiest way of accounting for them may be to surmise that our sun has been formerly sometimes more and sometimes less bright than it is at present. At all events it will be highly presumptuous to lay any great stress upon the stability of the present order of things; and many hitherto unaccountable varieties that happen in our seasons, such as a general severity or mildness of uncommon winters or burning summers, may possibly meet with an easy solution in the real inequality of the sun's rays." If our sun be a variable star diffusing heat in greater or less degrees at different times, or if it be a star growing old and burning out, the credit of the idea as well as of "lost" stars in the ocean of infinitude may justly be claimed, in our day at least, for this poetic and musical observer of the heavens. To shed a ray of light on this question of sunshine Herschel sought, but sought in vain, for temperatures in ages that were past. He could get none. He was not aware of the thermometers made by the school of Galileo

which had been made" was the British catalogue published by Flamsteed in 1712, and afterwards in better condition in 1725. It contains about 3000 stars. See Lalande, i. 284.

and lost to sight till Libri discovered them, and made them the common property of science. But, resolved not to be baffled, Herschel turned to the rise and fall of the price of wheat at Windsor as an indication of the warmth or coldness of the sun's rays. It was his only resource, and it was an idea worthy of a baffled man of science. But critics in the highest quarters attacked and ridiculed this seeker after truth as if he were guilty of supreme folly. Leaders of thought in every branch of science and in every department of life have to bear the brunt of ridicule from learned ignorance![1]

These were the first steps taken by Herschel, it may be said, in his quest after the plan on which Almighty Wisdom built the world of suns and systems. A farther step forward was made when he addressed himself to ascertain the motion of the sun and solar system through space. That there was such a motion he did not doubt. Some had held the same faith before him; astronomers as able had refused it a hearing. He converted it from faith to fact. What it means is that our sun with his most distant planet and comet, with every particle of matter that owns his sway, is travelling onward through space, round a centre of force apparently, and constrained by Newton's law of gravitation. Are these facts or fancies, leading features in the plan of creation or dreams of a mere enthusiast? Herschel not only believed they were facts; he set himself to prove it.

[1] The tables he took advantage of were those given by Adam Smith in *The Wealth of Nations*. The ridicule that was heaped upon him may be seen in the *Edinburgh Review*, and in a letter signed J. M., *Scots Magazine*, 1807, p. 329.

When he had proceeded some way in his inquiries, he received from a friend a copy of a catalogue of eighty stars made by Mayer of Göttingen in 1756, "and compared with the same stars as given by Roemer in 1706." Both Roemer and Mayer were men of the highest ability. Previously he knew this catalogue only in an extract which he found in a French book on astronomy. Setting to work on the new material thus furnished, and laying aside thirteen or fourteen of the stars as those he had already examined, he separated the others into two classes, those which went for his view of a motion of the sun through space, and those whose motions "must be ascribed to a real motion in the stars themselves." Mayer, admirable astronomer though Herschel admitted him to be, did not countenance the idea of a motion of the sun with all its planets through space. "Were it so," he wrote in 1760, "were the sun and all the planets and our home, the earth, advancing towards some quarter, all the stars in that part of the heavens would seem to open out, and those in the opposite quarter to come together, just as, when you are walking through a wood, the trees which are in front of you seem to separate from each other, and those which are behind to draw closer." Herschel, seizing on Mayer's illustration of trees in a wood, declared that these very changes were taking place among stars in the heavens. At the same time he was encouraged by a short tract sent him by the author, Dr. Alexander Wilson, Professor of Astronomy at Glasgow, and printed in 1777, entitled *Thoughts on General Gravitation and Views thence arising as to the State of the Universe.* A friendship sprang up

between the two men, and Glasgow seems to have become a favourite place of summer pilgrimage to Herschel. It was clear that he was favoured by the flowing tide of scientific thought. He took it at the flood: he even guided it into the channels along which it has since flowed in an ever increasing volume. It "is an arduous task," he said of this quest after our solar system's movement in space, "which we must not hope to see accomplished in a little time; but we are not to be discouraged from the attempt. Let us, at all events, endeavour to lay a good foundation for those who are to come after us." And this good foundation, by precept and example, he did lay.

With the boldness of a man who had confidence in himself and his instruments, he wrote: "I think we are no more authorised to suppose the sun at rest than we should be to deny the diurnal motion of the earth, except in this respect, that the proofs of the latter are very numerous, whereas the former rests only on a few, though capital testimonies." He founded this conclusion on a discussion of the motions observed in seven of the principal fixed stars. But in support of his view he also quoted a table of the proper motions of twelve stars in fifty years given by Lalande, motion in the two directions known to astronomers as right ascension and declination, corresponding to longitude and latitude on the earth. Twenty-seven motions altogether had to be accounted for. On the hypothesis of a general movement of the solar system through space, twenty-two out of these twenty-seven movements were explained. The five exceptions he "resolved into the real proper motion of the stars." He did not then know whether

the motion was of one star round a companion star, or round some far greater and immensely more distant sun.

The conclusion which Herschel arrived at was that the whole solar system was at that time moving towards the constellation Hercules in the northern sky, and that the star "λ Herculis is possibly as well chosen as any we can fix upon in that part of the heavens" for the point we are moving towards. He modified this view in 1804 on receiving more correct measurements from the Astronomer-Royal: "It will be necessary to mention that I have no longer supposed the solar motion to be directed towards λ Herculis. A point at no very great distance from this star has been chosen." As the direction of the tangent to the sun's orbit is constantly changing, this change of direction from age to age is unavoidable. He did not attempt to estimate precisely the rate of motion, but, "in a general way," he considered that it "cannot certainly be less than that which the earth has in her annual orbit." At the same time he expected that future astronomers would assist him in determining the direction of the solar motion; and he added that he had "begun a series of observations upon several zones of double stars," with the view of establishing or overturning his hypothesis. His estimate of the rate of the sun's motion may not be correct. Probably it is only from five to nine miles a second, or less than half what he made it: but science has accepted his view of the point, to which the solar system has, for an hundred years, been advancing. Recently α Lyræ (Vega) has been claimed as the point we are now making for.

In the years that followed his first papers on *The*

Construction of the Heavens, Herschel, with wider views, a better instrument, and a clearer insight into what he considered "the Laboratories of the universe, wherein the most salutary remedies for the decay of the whole are prepared," essayed a bolder flight into a world of "things, unattempted yet in prose or rhyme." Stars, clusters of stars, and nebulæ were the building stones, so to speak, out of which Almighty Wisdom constructed the starry sphere around our earth. How many of them exist, what are their relations to each other, and how are they arranged in space? were some of the questions to which he sought an answer. When he began the work of observation, he "surmised that several nebulæ might yet remain undiscovered for want of sufficient light to detect them. . . . The event has plainly proved that my expectations were well founded; for I have already found 466 new nebulæ and clusters of stars, none of which, to my present knowledge, have been seen before by any person." Great though the discovery was, it was only the beginning of others still greater. These nebulæ or little white clouds were similar to the Milky Way in the colour of their light, but apparently of immensely less extent. The first known of them, properly so called, was that of Andromeda, to which the attention of astronomers was directed by Simon Marius in 1612. Others were seen and recorded during the next century and a half, but the Magellanic clouds were visible to the naked eye and formed a striking spectacle in the southern heavens. The Dutch, who saw them in their voyages to India round South Africa, called them the Clouds of the Cape. Astronomers were

slowly feeling their way to a fuller knowledge of the "white clouds" they were discovering among the stars. La Caille, when working at a catalogue of about ten thousand stars in South Africa, set down the places of forty-two, which he saw in the telescope. He divided them into three classes; fourteen in which there was no appearance of stars; fourteen which were clearly composed of small stars; and fourteen which combined the characters of both these classes, small stars surrounded or attended by white spots. His labours were published in 1755. Herschel followed at the end of the century, vastly extended our knowledge of these singular objects, and completed the classification which the Frenchman began.

Turning his attention to the broad band of light known as the Milky Way, of which the various nebulæ "seemed to be portions, spread out in different parts of the heavens," Herschel at once solved the puzzle that then divided the astronomical world, Is it the diffused light of innumerable stars, or a shining gas? He describes it as beyond doubt "a most extensive stratum of stars of various sizes"; and "that our sun is actually one of the heavenly bodies belonging to it is as evident." These were two steps forward, but he did not stop with them. He examined that shining zone in all directions with a powerful telescope — a 20-feet reflector — piercing to the borders of its length, breadth, and thickness. He even undertook to count the number of stars he saw. He called this census of stars *gauging* the heavens. Four years afterwards, he called it *analysing* them, and spoke of his method as "perhaps the only one by which we can arrive at a knowledge

of their construction." He admits, however, that, in course of time, "many things must have been suggested by the great variety in the order, the size, and the compression of the stars as they presented themselves to his view." As the number of stars he counted increased, the brightness of the Milky Way increased; as the number diminished, its apparent brightness to the naked eye diminished also. The law of gravitation he felt certain existed among that vast multitude of suns and systems, just as it exists in pulling a stone to the ground. At first this was mere suspicion. More than twenty years elapsed before he could say it was an established fact.

He continued his review of the heavens, or his gauging of the stars. The results were so marvellous that all the world — men of science, the common people, even children at school—wondered. Sometimes he saw, in a small celestial space, as many as 250, or 340, or 424, or 588 stars; at other times he counted only 3 or 4, 5 or 6. The star-wealth of some of these regions was so vast that in one only 5° in breadth—a very small part of the whole vault of the heavens — there were about 330,000 shining suns or stars! The Chancellor of the University of Halle, who visited Herschel shortly before his death, evidently got from the astronomer himself that he had "often known more than 50,000 pass before his sight within an hour," and he records his own wonder, and the wonder of men generally, while these discoveries were still fresh in their minds, that "after the invention of his instruments, I. H. Schroeter, the celebrated astronomer of Lilienthal, might well compute the fixed stars in the southern

and northern hemispheres at more than twelve millions in number."

The average of many hundreds of these gauges gave him what he called "the contents of the heavens." Where the stars were exceedingly crowded, "no more than half a field was counted, and even sometimes only a quadrant"; but the result of these vast labours was that the Milky Way could not be described as other than "*a very extensive, branching, compound congeries of many millions of stars*; which, most probably, owes its origin to many remarkably large as well as pretty closely scattered small stars, that may have drawn together the rest." Imagination stands appalled at the thought of millions of shining stars, each of the same kindred as our sun, and each, it may be supposed, with a train of habitable worlds like his planets, all circling round their central orb. The littleness of man, the smallness of human life, the meanness of its petty details, that usually fill the whole horizon of human thought, are dwarfed into nothingness in presence of these stupendous realities, till even they become insignificant before the nobler and more inspiring conception of the grandeur of the soul, which measures and weighs these innumerable suns, which takes them up in the hollow of its hand, which deals with them as playthings for its leisure moments, and which says to every one of them, I am greater and of more worth than thou, yes, greater than all your millions put together. "There is no speech nor language where their voice is not heard."

By these star gauges Herschel did a service to the world, for which humanity can never be sufficiently

thankful. The plan as well as the labour of thus estimating "the contents of the heavens," and lifting man's mind to a higher level than it ever attained before, were altogether his own, unless we add that his devoted sister Caroline shared the labour and, it must be added, the dangers of the work. What a vista of eternity and infinitude was unfolded by the musician of Bath! It seemed as if he had built a bridge for thought to span the gulf which separates the finite from the infinite, the temporal from the eternal, in this incredible profusion of suns and systems, of inconceivable spaces and times.

Of the length, breadth, and thickness of these strata of millions of stars that form the Milky Way, we have but the faintest conception. Still, Herschel made an estimate, which shows the immensity of space covered by this island of stars in the ocean of infinitude, if we may still presume to speak of it in these terms. "In the sides of the stratum opposite to our situation in it, where the gauges often run below 5, our nebula"—the white cloud called the Milky Way—"cannot extend to 100 times the distance of Sirius." But we know now, what Herschel did not know, that light, which darts from the sun to our earth in eight minutes, takes about ten years at the same rate to travel the distance between Sirius and us. One hundred times that distance would be traversed by light in 1000 years. And, if the farthest-off stars of the Milky Way are nearly five hundred times as far away from our earth as Sirius, the swift messenger who brings us tidings of them would be five thousand years on his journey, and could only tell us what was then taking place, not what may be happening now. Herschel

believed that his telescope sounded space to this and far greater depths without finding traces of nebulosity —gas or star dust—in the regions it reached.[1] He said also that his telescope sounded the depths of past time not less than of space. Be his ideas reality or romance, they give us a sublime conception of the greatness and worth of the human mind buried in its pigmy house of clay, and chafing against the chains that bind it to earth and time.

Sublime though Herschel's conceptions were, he did not conceal from himself or others that "a certain degree of doubt may be left about the arrangement and scattering of the stars" in the Milky Way. They were founded on the supposition of "numberless stars of various sizes, scattered over an indefinite portion of space in such a manner as to be almost equally distributed throughout the whole." This was a large supposition to make; it is not correct, and it was a corner-stone that might be knocked away at any moment. The barriers he required to overleap were the distance and the relative sizes of the stars. These barriers remained insurmountable during his lifetime. It was next assumed, for it could not be said to be proved, that "there is but little room to expect a connection between our nebula"—the Milky Way— "and any of the neighbouring ones; . . . for if our nebula is not absolutely a detached one, I am firmly persuaded that an instrument may be made large enough to discover the places where the stars continue onwards. A very bright, milky nebulosity must there undoubtedly come on." At that time Herschel imagined space to be a vast ocean of light-bearing ether,

[1] *Phil. Trans.*, pp. 249, 247 (100 times), 497 times.

studded with continents and islands of stars, which he called nebulæ, clusters, or groups. The Milky Way, with its many millions of shining suns, is one of these thickly peopled islands, separated from many others as rich or perhaps richer of worlds, in this infinite ocean. Of these nebulæ or clusters, or star islands, he had, up to that time, counted "more than 900, many of which, in all probability, are equally extensive with that which we inhabit; and yet they are all separated from each other by very considerable intervals. Some there are that seem to be double and treble; and though with most of these it may be that they are at a very great distance from each other, yet we allow that some such conjunctions really are to be found. But then these compound or double nebulæ still make a detached link in the great chain." He fell from some of these views at a later period, wholly or in part.

Herschel delighted in these attractive speculations. In a paper on the power of telescopes to penetrate space, one of the conclusions he came to was that, while his 20-feet reflector "might possibly have reached to some distance beyond the apparent bounds of the Milky Way," his 40-feet would reach stars from which light would take about two millions of years to reach our earth. A ray of light revealing to us the history of stars as it was two millions of years ago! If such things are dreams or miscalculations, they soar into the sublimest regions of mortal thought. More amenable to arithmetic is his calculation, that it will require not less than 598 years, of 100 working hours each, to take a census of the stars by looking with his 40-feet "only one single moment into each part of space, and, even then, so much of the southern

hemisphere will remain unexplored as will take up 213 years more to examine." In these numbers Herschel was perhaps mistaken. Struve at Pulkowa found 80 nights suitable out of 120 clear nights; but Sir John Herschel's experience at the Cape of Good Hope gave him the whole or parts of 131 nights in 1836, and at least 100 in the following year. The estimate of 598 years, or rather 811, by Sir William Herschel may be set down as excessive.

Herschel does not appear to have been altogether satisfied with the position he had taken up. It was not warranted by pure and inductive science. The foundation on which alone he could build with confidence had not been laid, the distance of fixed stars and nebulæ. "To these arguments," he says, "which rest on the firm basis of a series of observation, we may add the following considerations drawn from analogy." Science demands something more trustworthy than arguments and analogy. Mathematical science is not content with probability: it demands demonstration, and this he could not give. He had a distinct idea of an ocean, we shall say, of ether, transmitting light. In that ocean are thousands of floating islands, each composed of myriads or millions of shining worlds, all communicating with each other by far-piercing sunbeams. What the telegraphic messages thus sent from sun to sun, from island to island, may be, Herschel had no means at first of knowing. He came to understand and even read some of these messages in later years. We are able to read more of them now, for they tell the sizes of suns, their rates of motion, their direction of motion, and other pieces of star history incredibly interesting to curious man. Herschel did not imagine

that this ocean of ether is in any degree impervious to light. His friend Dr. Olbers, of Bremen, suggested that it might be. Precisely as the glass or the horn, through which rays of light pass, keeps part of them back or absorbs them, the infinite ocean of ether may have a similar effect, though in a vastly less degree. This apprehension remains a mere speculation to this day. Sometimes these islands of stars were broken into clusters of stars showing magnificent colours, and forming the most splendid objects that can be seen in the heavens. They seemed to concentrate round a centre. The Milky Way is one of these islands, of which the population consists in suns and worlds. Others, separated from it and from each other, and even apparently changing their shape from age to age, are "generally seen upon a very clear and pure ground without any star near them that might be supposed to belong to them." With all this sublimity of exposition and explanation, Herschel at the same time asks for consideration from critics and readers, "for, this subject being so new, I look upon what is here given partly as only an example to illustrate the spirit of the method."

The idea Herschel formed and then figured of the shape of the Milky Way may be best understood by comparing it to the palm of the hand with only two fingers—the middle and the forefinger—and these stretched fully out. Our sun he supposed to be near the roots of the fingers, looking out into open space through the interval between them. He had the idea also that our star-island "has fewer marks of antiquity upon it than the rest." He believed that its stars "are now drawing towards various secondary centres, and will in time separate into different clusters so as

to occasion many subdivisions." In fact, he "ascribes a certain air of youth and vigour to many very regularly scattered regions in our sidereal stratum." He imagined also that "some parts of our system seem to have sustained greater ravages of time than others," so much so that "in the body of the Scorpion is an opening or hole" of at least four degrees broad, through which, as through a window, infinite space can be surveyed outside, till telescopes of greater power pierce the darkness, and, it may be, reveal to our eye Milky Ways in the far Beyond. One of them, near the constellation called the Southern Cross, had long been familiar to sailors in southern seas as the Coal Sack of the Milky Way, a pear-shaped oval almost destitute of stars, with which the regions around are crowded and brilliant. "The purity and clearness of the heavens are remarkable," he says, "when we look out of our stratum at the sides towards Leo and Virgo on the one hand, and Cetus on the other; whereas the ground of the heavens becomes troubled as we approach towards the length or height of it." These troubled appearances seemed to arise "from distant, straggling stars that yield hardly light enough," till, after a long examination of these troubled spots, the eye gets accustomed to the dimness, and the stars that caused the troubling come into view.

When Sir John Herschel went to the Cape of Good Hope in 1833, to survey the southern heavens as his father had surveyed the northern half a century before, his aunt Caroline wrote to him, "It is not *clusters of stars* I want you to discover in the body of the Scorpion (or thereabout), for that does not answer my expectation, remembering having once heard your father,

after a long awful silence, exclaim, 'Hier ist wahrhaftig ein Loch in Himmel!'[1] and, as I said before, stopping afterwards at the same spot, but leaving it unsatisfied." The nephew attended to her wishes, *rummaged* Scorpio with the telescope, and found many blank spaces "without the smallest star. . . . Then come on the globular clusters, then more blank fields, then suddenly the Milky Way comes on in large milky nebulous irregular patches and banks."

Other Milky Ways than the star-island, to which we belong, "which cannot well be less but are probably much larger," Herschel at one time believed he saw in the white clouds, which float in the depths of space, unseen by the naked eye. Sometimes his telescope resolved them into brilliant star-dust, scattered like shining jewels on the dark background of the heavens: and sometimes not. That they are at immense, at inconceivable distances from the solar system and from each other, is evident. How far, it would be rash to say. But Herschel's enthusiasm overleaped all boundaries of prudent reticence. Some of them may be "600 times the distance of Sirius from us"; other clusters "cannot well be supposed to be at less than six or eight thousand times that distance." Light, the swiftest messenger we know, light, which can journey round the earth eight times in a second, would take six thousand years to bring us a message from the nearest of these clusters, or more than eighty thousand years from the more remote. If his views prove correct, a messenger of wing so swift, and of foot so tireless, may well be regarded as an angel of the Almighty.

"Here indeed is a hole in the Heavens!"

Speculations so attractive by a watcher with an eye so keen to detect chinks in the armour, that concealed nature's most secret workings, could not fail to be affected by new facts, as they forced themselves on his observation. He found in course of years that "the hypothesis of an equality and an equal distribution of stars is too far from being strictly true to be laid down as an unerring guide in this research. . . . This consideration is fully sufficient to shew that, how much truth soever there may be in the hypothesis of an equal distribution and equality of stars, when considered in a general view, it can be of no service in a case where great accuracy is required." Fifteen years later he wrote: "When we examine the Milky Way, or the closely compressed clusters of stars, this supposed equality of scattering must be given up." It is clear that, until the distance and mutual relations of the fixed stars were ascertained, mere speculations on their size and brilliance were out of place. He found also that Cassini's classification of nebulæ was at least incomplete or defective. He was leaning to the belief that some of the nebulæ are masses of shining gas, while there may be vast masses or regions of it still dark; but these and other matters must be referred to another chapter. It is enough in the meanwhile to say that twenty-five years of further research wrought a change on the views he once expressed. But they also brought into distincter prominence the changeful character of even the starry heavens. They had wrought no change on the awe with which his contemporaries, however trifling they might be, regarded "the profusion of worlds on worlds" revealed to their view. The immense multiplication of life on our

little earth is on the same scale and partakes of the same procedure as this profusion in creating worlds. Unity of design to the remotest bounds of nature is a conclusion that plainly results from Herschel's discoveries.

The worst objection taken to the writings of this midnight watcher was the strange English he sometimes used. "Stupendous as Mr. Herschel's investigations are," Horace Walpole wrote to a friend, "and admirable as are his talents, his expression of '*our retired corner of the universe*,' seems a little improper. When a little emmet, standing on its anthill, could get a peep into infinity, how could he think he saw *a* retired *corner* in it? . . . If there are twenty millions of worlds, why not as many, and as many, and as many more? Oh, one's imagination cracks!"[1] "To the inhabitants of the nebulæ of the present catalogue," Herschel wrote, "our sidereal system must appear either as a small nebulous patch; an extended streak of milky light; a large resolvable nebula; a very compressed cluster of minute stars hardly discernible; or as an immense collection of large scattered stars of various sizes." Well may we repeat in sobriety and humility what the poet, in contempt and fun, uttered about the same time,

> "Oh wad some Power the giftie gie us
> To see oorsels as ithers see us."

The last two papers which Herschel wrote on *The Construction of the Heavens* were given to the world about four years before his death. They show the same grasp of details, the same enthusiasm in working out

[1] *Letters*, vi. 461, 258.

a lofty theme, the same insight into general principles, as illumined the first paper he wrote on the subject thirty-five years before. Although his sun was nearing its going down, there was no loss of its morning brilliance. "Of all the celestial objects consisting of stars not visible to the eye," he writes, "the Milky Way is the most striking. . . . Its general appearance, without applying a telescope to it, is that of a zone surrounding our situation in the solar system, in the shape of a succession of differently condensed patches of brightness, intermixed with others of a fainter tinge." But his latest observations led him to believe that the Milky Way is a fathomless, and comparatively thin stratum of stars, of which his 40-feet reflector would sound the depths "to the 2300th order of distances and would then fail us." He imagined also he had "shown how, by an equalisation of the light of stars of different brightness, we may ascertain their relative distances from the observer, in the direction of the line in which they are seen." Among these last words was his expressed conviction that the Milky Way is the most brilliant, and beyond all comparison the most extensive sidereal system. He thus held to the end that it was one of many systems, of which it bulked in his eyes as a great continent in an ocean of ether, while the nebulæ are outlying islands. Within the bounds of the Milky Way he believed that all our stars, visible to the naked eye, are contained. If an 18-inch globe represented all these stars, it would require a line 45 feet long to be added to express the distance of the 734th order of stars, and, while he saw many of the 900th or 980th order, he was convinced that his 40-feet telescope would penetrate space

to the 2300th order. We can only say with Horace Walpole on looking at these figures, One's imagination cracks! But definite distances had not been determined then, and are not determined yet.

Whether these be the dreams of an enthusiastic romancer, or the sober facts of science, there can be no doubt that the observations on which they rest are a delightful mixture of poetry and scientific truth. Thickly strewn over the pages of a scientific memoir are such entries as these: "The stars are so exceedingly close and small that they cannot be counted"; "a beautiful cluster of stars"; "stars are so small that I can but just perceive some and suspect others"; "light without stars"; "a brilliant cluster"; "a coarse cluster of large stars of different sizes"; "a rich cluster of very compressed stars." The wealth of the heavens passes both the language and the comprehension of man. Star-dust, sparkling with more than diamond lustre on the dark background of the heavens, has become a common figure of speech. Jewels of silver, jewels of gold, rubies, diamonds, and sapphires are seen in admirably distinct disorder in the great mirror of the telescope. The prose of the heavens surpasses the brightest poetry of earth.[1]

Whether William Herschel was justified in holding to the theory of an ocean of ether with thousands of dimly seen Milky Ways floating about in it, or whether he modified his view into a belief that the starry worlds, seen from our earth, are parts of a connected whole, is of little consequence in these days. Perhaps he was himself in doubt which view to take. But he was nearer to realising infinitude of space and eternity

[1] *Phil. Trans.*, 1818, pp. 437–50.

of time—if the phrase be allowable—than any man ever was before him. He marks an era in the progress of human thought and experience, for his words leave on the mind of a reader an awful impression of unspeakable vastness in space and time, of multitudinous arrangements for working out with singular ease and success some vast whole, and of undiscovered purposes in the designs of a Being to whose nature ours is of kin, though we feel ourselves to be but nothings, or less than nothings, in His presence. To ignore or deny this impression is to do an injustice to humanity.

CHAPTER IX

THE SUN

So carefully and persistently was the sun studied by Herschel that, for the sake of clearness, it is advisable to arrange his work not in the order of time, but according to the subject he treats of. He began at an early period to watch the sun's face, and to make experiments with the view of discovering its history, past and future. Could he but read that history or even a chapter of it, he felt that he would be able to read the history of other suns as well as ours, and perhaps to lay a foundation for fellow-labourers in the same cause to build a temple to science on. He succeeded beyond his wishes, or at least his hopes.

The first thing he endeavoured to ascertain was, whether the sun was stationary or nearly stationary in the heavens. Astronomers had already discovered that its immense fiery globe had a day like our earth, that is, that it turned round on its axis precisely as the earth does. The time it takes they found to be $25^{d}\ 7^{h}\ 48^{m}$ of our reckoning. This is the length of the sun's day. But Herschel asked if the sun had not a year as well as a day, a time—vast, immeasurable, perhaps—in which it revolves round a centre, hidden from man's knowledge, but not from man's sight, if he only knew where to look for it. Herschel looked for

an unknown centre. He did not find it, but he believed, as we have already seen, first, that the sun was moving among the stars, and second, that it was moving towards a spot in the constellation Hercules in the northern sky.

As the sun is the source of light and heat, and both of them had to be considered in his observations, it was natural that Herschel should turn his thoughts to the solar spectrum, as we call what is commonly spoken of as the rainbow. A glass prism produces the same effect on a beam of sunlight as a raindrop or a cloud curtain composed of millions of them: it divides or decomposes the white light of one sun into that of seven suns of different colours, red, orange, yellow, green, blue, indigo, violet, and it also bends or refracts them from the straight line the sunbeam would otherwise pursue. The red is the least bent, the violet most. By the refraction or bending is meant what is seen by thrusting one half of a walking-stick into water, and keeping the other half out of it in the air. But it happened that in shielding his eye from the sun when looking at its disc through a telescope, Herschel had used glass of various colours to dim the glare and heat. This experience was fatal to the use of glass coloured red. "I began with a red glass," he says, "and, not finding it to stop light enough, took two of them together. These intercepted full as much light as was necessary; but I soon found that the eye could not bear the irritation, from a sensation of heat, which, it appeared, these glasses did not stop. I now took two green glasses: but found that they did not intercept light enough. I therefore smoked one of them: and it appeared that, notwithstanding they

still transmitted considerably more light than the red glasses, they remedied the former inconvenience of an irritation arising from heat. Repeating these trials several times, I constantly found the same result." How to see the sun distinctly without inconvenience or danger from the heat continued to occupy his thoughts for years. "I viewed the sun through water," he wrote in 1801. "It keeps the heat off so well, that we may look for any length of time, without the least inconvenience." "Ink diluted with water gave an image of the sun as white as snow; and I saw objects very distinctly, without darkening glasses."

Herschel introduced his papers on the sun's light and heat with a wise remark, which proved him to be as good an observer in the world of mind as in that of matter. "It is sometimes of great use in natural philosophy to doubt of things that are commonly taken for granted; especially as the means of resolving any doubt, when once it is entertained, are often within our reach. . . . It will therefore not be amiss to notice what gave rise to a surmise, that the power of heating and illuminating objects might not be equally distributed among the variously coloured rays." The experiments, which he then made on the light and heat given out by each colour of the spectrum, were admirably imagined and beautifully carried out. He was really engaged on a continuation of Newton's experiments on sunbeams, but the field of research was new and untrod. Gradually the questions to which he sought answers began to take shape more distinctly in his mind. When a prism intercepts a beam of sunlight, let into a darkened room through a hole in the window shutter, and the band of coloured light, five times as long as it

is broad, falls on a screen placed behind the prism, is the whole band equally heated or equally luminous? and is the whole sunbeam found decomposed into the colours seen? Regarding equality of heating and illumination in the various colours, Herschel's experiments made it plain that at the red end there are visible rays, which are hotter than those in any other part of the coloured band or spectrum. The heat he found diminishing as the refrangibility increases from the red to the violet end. The power of illuminating an object, on the contrary, increases from the red to the orange, from the orange to the yellow, and reaches its greatest intensity between the yellow and the green, after which it rapidly decreases in the blue, more so in the indigo, till it becomes "very deficient in the violet." One of his experiments, by the help of a microscope, was with a guinea:—"*Red* showed four remarkable points: very distinct. *Orange*, better illuminated: very distinct. *Yellow*, still better illuminated: very distinct: the points all over the field of view are coloured; some green; some red; some yellow; and some white, encircled with black about them. Between yellow and green is the maximum of illumination: extremely distinct. *Green*, as well illuminated as the yellow: very distinct. *Blue*, much inferior in illumination: very distinct. *Indigo*, badly illuminated: distinct. *Violet*, very badly illuminated: I can hardly see the object at all."

His second inquiry was, Is a sunbeam passing through a prism and received on a screen behind it represented entirely by the coloured and visible band of the spectrum? His answer to this question was a distinct *no*, and a hinted suspicion that the *no* extended or might extend farther than it was in his power to

prove. He could and did show that a thermometer rose in passing from the violet to the red end of the spectrum: but he did more. He placed the thermometer beyond the visible red, and found that, as it continued to rise, heat-rays, invisible to the eye and less bent from the straight path of the sunbeam, gave the greatest heat. He must have asked himself, Is there not something similar at the violet end; but he had not the means of answering the question. He did what was next best. He asked a question pregnant with great results, and destined to bear an abundant harvest for the welfare and instruction of man. "It may be pardonable if I digress for a moment, and remark, that the foregoing researches ought to lead us on to others. May not the chemical properties of the prismatic colours be as different as those which relate to light and heat: . . . they may reside only in one of the colours." To this question he could neither give nor get an answer. A short time passed, and the answer came from Germany and, independently, from England. "The existence of solar rays accompanying light, more refrangible than the violet rays, and cognisable by their chemical effects, was first ascertained by Mr. Ritter." They were called "The dark rays of Ritter," and "appeared to extend beyond the violet rays of the prismatic spectrum, through a space nearly equal to that which is occupied by the violet." "Paper dipped in a solution of nitrate of silver" was used to prove the existence of these chemical rays and to introduce the days of photography. It was most fitting that it should be so. An astronomer led the way in this new quest after invisible rays; chemistry supplemented his discoveries

by paving the way for photography, and paid back its debt to astronomy by shortening the processes of its art, and faithfully recording the face of the heavens, as the most skilful draughtsman could not do. Truly, Herschel was a seer, whose imagination captured truth, though men less gifted mocked him as a dreamer. The equerry in Windsor Castle was justified in assuring Miss Burney that time would do justice to Herschel, as it had done to Newton.

Herschel's mistakes, in his subsequent inquiries, arose largely from his belief in Newton's theory that light-giving bodies, like the sun, emit infinitely small particles, which enter the eye and affect the retina so as to produce vision. Hence he spoke of the momenta of these particles. His contemporary, Dr. Thomas Young, maintained that light, like air, was produced by waves propagated at a vast rate of speed, and in immensely short lengths, through a universally diffused and infinitely rare medium, called *ether*.[1] A Frenchman, Fresnel, has got most of the credit of establishing this theory. But the third question asked and answered by Herschel in these papers about the sun was, Is light the same or different from heat? His experiments were carefully arranged and as carefully made, and the conclusion reached was that they are different. He also wrote two long papers on the coloured rings produced when two watch-glasses, or one and a plane glass, are pressed together so as to leave a thin plate of air between them. Amid un-

[1] Dr. Young, "The Bakerian Lecture, *Phil. Trans.* for 1802, pp. 14, 15, "A luniniferous ether pervades the universe, rare and elastic in a high degree." He was well abused by an Edinburgh Reviewer for this Lecture.

undoubtedly excellent observations he was too hasty in what he then wrote, and too rash in the conclusions he then drew. But let it be recorded to his honour that to him belongs the credit of first sending the beams of Sirius and other sunny stars through a prism, for the purpose of determining whether their light is like our sun's or not. It was a most brilliant idea, carried out before the world was ready to receive it.

The great question Herschel set himself to solve regarding the sun was, What is it? He knew, as all men had known, that it was a vast fiery ball ruling earth and sky; but he saw, as they saw, nothing save the outside of the ball. Was it a mighty furnace within as it was without? In Newton's days, two or three generations earlier, there were people who "supposed the sun to be cold," although Newton easily showed that, to "a body hard by the sun, his heat would be 50,000 times greater than we feel it in a hot summer day, which is vastly greater than any heat we know on earth."[1] Herschel was aware that the spots, the black spots on its face, were vast dark holes in its white brightness, so large that they would let the earth dive in, and be at a thousand miles' distance all round from the burning, blazing clouds. But while he knew this, he had also learned from the writings of others that these black rifts were careering over its face from west to east at the rate of more than a mile every second. What did it all mean, was the question he wished answered. Fabricius in 1611, and Galileo about the same time, divide between them the honour of discovering these spots on the sun's face. The former tells the story of his first sight of a spot, of his

[1] Brewster, *Life*, ii. 455.

own and his father's keenness in viewing it till the heat affected their eyes, of his extreme impatience till morning again revealed to him in the sun itself what he thought was only a cloud, and of the incredible delight with which he welcomed the strange stain on the sun's brightness, but removed a little from the place where it was seen the day before—he tells a true story with the pen of a romancer inventing a world of wonders. The darkened room, the hole in the shutter, the sheet of white paper to receive the bright image, and the sun's rotation on his axis then burst upon the world in his pages.

Some imagined that these vast fields of darkness were smoke from gigantic volcanoes on the sun; others considered them to be a mighty expanse of scum floating on a burning ocean, or dark clouds swimming in highly heated gas. But Herschel's telescope told him they were immense pits dug somehow in the shining and fiery brightness, while waves of fiercer brightness surged round the edges in crests of vast height, for which the name *faculæ*, or torches, had been long before invented. Over many million of square miles of the sun's surface this rising of fiercely heated waves and this digging out of black hollows were continually going on in a greater or lesser degree. As many as forty of the latter were once seen by Herschel, when he was watching Mercury, so to speak, picking his way amongst them during his passage across the sun's disc. Other observers laid claim to counting no fewer than fifty at one and the same time. What were they? In July 1643 Hevelius saw a procession of spots and bright crests more than a third of the sun's surface in

length, or nearly twice as far as the distance of the moon from the earth! Then spots were seen of such a depth that when they reached the sun's edge they made a notch on the rim. It was evident they were not volcanoes spouting forth solid matter to immense heights and blackening with solar smoke the photosphere, as Schroeter called the envelope of light which clothed the sun. They were not dark bodies like planets circling round this fiery ball. Nor were they masses of black scum floating on an ocean of brightness. In 1779 Herschel saw a great spot which appeared to be divided into two parts. One of them was more than thirty-one thousand miles in length, the other was about twenty thousand, and a ridge of shining light separated the one from the other. Four years later he observed another, "a fine large spot," and followed it to the edge of the sun. He came to the conclusion that he was looking into a vast pit, with "very broad, shelving sides," on to "the real solid body of the sun itself." Eight years after, in 1791, he came to the same conclusion regarding another large spot: it was a pit below the level of the bright surface; round the dark part it had a broad margin less bright than the surface, and also lower down. Accompanying the spots were the *faculæ*, as Hevelius called "the ridges of elevation above the rough surface" of the sun. "About all the spots the shining matter seemed to have been disturbed; and was uneven, lumpy, and zigzagged in an irregular manner." These waves or ridges of brightness are of immense extent, but Herschel objected to call them torches, as "they appeared like the shrivelled elevations on a dried apple, extended in length, and most of them

joined together, making waves, or waving lines." In 1801 he had advanced to the "strong suspicion that one half of our sun is less favourable to a copious emission of rays than the other; and that its variable lustre may possibly appear to other solar systems, as irregular periodical stars are seen by us." In the same paper he records in his observations that he counted at one time 45 "openings" or spots, on the following day 50, and three days later above 60. A cloud, hanging over one of these openings, was seen to move a third of the way across the mighty chasm in fifty-eight minutes.

Herschel's theory of the sun then may be thus stated. There is first the region of "luminous solar clouds" which, adding also the elevation of the *faculæ*, cannot be less than 1843, nor much more than 2765 miles in depth. These solar clouds he compares in density with the aurora borealis of our skies. Underneath this envelope of brightness is the sun's atmosphere, which may be so clouded as to shield the body of the sun and the beings, who live there, from the intense heat and glare above. The body of the sun lies still lower, and "is diversified with mountains and valleys." Some may deem it the horrid abode of lost souls; others may see in its cool retreats the home of blessed spirits. But so imbued is man's mind with the idea of unbearable heat in the sun that, in a court of law, belief in its coolness was at that time quoted as a proof of insanity, and of incompetence in a man to manage his own affairs.[1] This, in short compass, is Herschel's view of the constitution of the sun. It is largely founded on the theory of his friend Wilson, the Professor of Astronomy in the University of

[1] *Scots Magazine*, 1807, p. 329.

Glasgow. So far as spots are concerned, it works out to an attractive and popular resemblance to truth. Suppose a disturbance—call it hurricane or tornado—to take place in the solar atmosphere. Everything is on a gigantic scale, mountains, winds, waves in this ocean of light. A mighty updraft from below rolls back, for a longer or shorter time, the luminous solar clouds. Into the vast pit thus laid open these clouds pour a flood of light on the body and cloudy atmosphere of the sun. The former looks black against the light, but reveals mountains upwards of three hundred miles in height; the latter, with its shelving sides, returns more of the light, and is less black; while the shining matter, rolled back into waves of enormous length and height, is heaped up in fiery storms round the vast gulf. The dark body of the sun is called the *macula*, or spot; the better lighted atmospheric shield, the *penumbra*; and the heaped-up waves the *faculæ*, which give the sun's surface the roughness of aspect it presents.[1]

This was all that Herschel saw or imagined. It was far within the truth for awe-inspiring beauty, and for the gigantic movements of these "luminous solar clouds." Had he seen the "blood-red streak" of the total eclipse of 1706, or the "corona" and "the ruddy clouds" of that of 1715, the science of astronomy would have been perhaps half a century in advance of the position he left it in at his death. He did not see

[1] Had Herschel known and reflected on the letter of Sir Isaac Newton printed in his *Life*, ii. 455, he would probably not have published this theory. "The whole body of the sun, therefore, must be red-hot" is Newton's conclusion. Even then it would look black against the surface luminous clouds.

either blood-red streak or corona. There is no reason to believe that he even read of them. His pigmy mountains of three or four hundred miles were molehills to the vast tongues of red flame shot up from the burning ocean of the sun's surface to a height of 200,000 miles in a few minutes, rising from and falling back into that ocean's bosom in a couple of hours. Herschel would have revelled in these gigantic strides of living flame. He would have cast away his theory of solid body, atmosphere and luminous solar clouds. Probably he would have held fast to his comparison of the light-clouds to our northern lights, and to his idea that the comets help to maintain the light and heat of our sun. How his glory is kept up from age to age, from millennium to millennium, we know as little as he did. Truly we are only at the beginning of our knowledge of this and other glorious stars; Herschel may have thought, and probably did think, that we were nearly at the end.

CHAPTER X

PLANETS AND COMETS

THE first of the heavenly bodies to which Herschel really turned his eyes with the longing of a traveller in an untrodden land of romance, appears to have been the planet Saturn. He was then forging the instruments which were destined to disclose the hidden things of creation, and to give an impulse to the study of them, that has gone on from wonder to wonder till the present day. He was keeping a journal, making entries of what he saw, and laying a foundation for future progress. But his method of writing was somewhat peculiar. His papers were to a large extent copies of entries made in his journal, or the impressions he received at the moment while sun or star or planet was under his eye. There was thus room for mistakes, which it is not surprising that he fell into; the wonder is that he fell into so few. Of mistakes resulting from this hasty method of working he was himself conscious; but it led to another inconvenience. He did not delay publishing his views till he was perfectly sure of their accuracy. The result was diffuseness of statement and unnecessary returning to the same subject. To give his views in the order of time would thus be wearisome and useless. We shall keep to the order of subjects, bringing them, as far as possible, to a focus.

The planet Mercury did not receive much attention from Herschel; but, slight though his interest in it seems to have been, he could not make it a field of observation without shedding light on things then unknown, and afterwards forgotten. As a transit or passage of the planet over the sun's face was due at Windsor in the early morning of November 9, 1802, and Herschel's "apparatus[1] for viewing the sun was then in the highest perfection," he was on the watch for what might happen. The weather proved as favourable as he could wish, and more than forty dark spots were counted on the sun's disc. A little black pea traversing the disc among dark spots of vastly greater size, it might have been feared, would be lost to view or only seen now and again. On the contrary, the black dot was easily seen during the four hours that remained of its passage across. As the sun rose higher, "the corrugations of the luminous solar surface up to the very edge of the planet" were visible with a 10-feet reflector. "When the planet was sufficiently advanced towards the largest opening," or spot, "of the northern zone, he compared the intensity of the blackness of the two objects; and found the disk of Mercury considerably darker, and of a more uniform black tint, than the area of the large opening." As it approached the edge of the sun, the whole of its disc was "as sharply defined as possible; there was not the least appearance of any atmospheric ring, or different tinge of light, visible about the planet." As the black dot vanished on leaving the bright body of the sun, there was not the slightest distortion of the sun's limb or in its own figure. The

[1] The mirror of the reflector used on this occasion was made of glass.

planet was snuffed out at once on leaving the sun's body. Things were somewhat different with the planet Venus.

Venus had for many years been the object of close research by Schroeter, a most painstaking observer of Lilienthal, then a well-known observatory in the duchy of Bremen. Her appearance had also been carefully studied by Herschel for nearly twenty years. The former made out that he had measured on her surface lofty mountains six times higher than Chimborazo, or about twenty-three miles in height. The latter could see nothing of the kind, and poked some grave scientific fun at his friend, who complained, in a learned paper, that he could not "reconcile it to the friendly sentiments which the author has always hitherto expressed towards me, and which I hold extremely precious; though perhaps to others it may not have the same appearance." Boscovich's epigram on the planets had come true in the case of these astronomers—

> "'Twixt Mars and Venus as this globe was hurled,
> 'Tis plain that love and war must rule the world."

Schroeter attacks Herschel for misrepresenting, or, on insufficient grounds, rejecting his views. Herschel appears not to have retorted any more than he did when attacked elsewhere by others. It was wise; but he found that the Lady Venus may be as much a source of quarrel, when she walks in unsurpassed brightness among the stars, as when she awakens the feelings of mortal hearts on earth.

As this was the only scientific quarrel in Herschel's life, it is worth while to show how small it was. Far different were the quarrels which caused annoyance

and grief to the friends of Newton, Hooke, Flamsteed, Leibnitz, Bernoulli, Laplace, and which render their lives sometimes most unpleasant reading. A quarrel for the maintenance of truth and right is a necessity of life in a world, where falsehood and wrong seem often to have the best of it; but the meannesses and selfishness of scientific quarrels have little or nothing of this nobility about them. "The result of my observations would have been communicated long ago," Herschel wrote for the Royal Society, "if I had not still flattered myself with the hopes of some better success, concerning the diurnal motion of Venus; which, on acccount of the density of the atmosphere of this planet, has still eluded my constant attention as far as concerns its period and direction. Even at the present time I should hesitate to give the following extract from my journals, if it did not seem incumbent on me to examine by what accident I came to overlook mountains in this planet, which are said to be of such enormous height, as to exceed four, five, and even six times the perpendicular elevation of Cimboraça, the highest of our mountains. The same paper which contains the lines I have quoted, gives us likewise many extraordinary accounts, equally wonderful: such as hints of the various and singular properties of the atmosphere of Saturn." Then he proceeds to speak of Schroeter's measures as "defective"; the mirror of the 7-feet reflector used as "considerably tarnished"; and the "calculations (as) so full of inaccuracies, that it would be necessary to go over them again." The Lilienthal observer did not like this plain speaking.

To these somewhat sharp, but perhaps deserved criticisms, Schroeter replied in 1795. "Though it is a

satisfaction to me that Dr. Herschel last year found my discovery of the morning and evening twilight of Venus's atmosphere to be confirmed, as I could not hope to have obtained such an important confirmation so early, considering the excellent telescopes required, and that a favourable opportunity for such observations occurs but seldom: yet the paper on the planet Venus, which this great observer has inserted in the *Phil. Trans.* for 1793, contains unreserved assertions, which may be easily injurious to the truth, for the very reason that they have truth for their object, and yet rest on no sufficient foundation." And Schroeter then endeavours to show that Herschel's paper contains misrepresentations or unsatisfactory proof of mistakes committed by him.

It was a small quarrel at the worst, in which these two friends engaged, a very different quarrel from the disputes and angry encounters that disgraced Leibnitz, and Bernoulli, and Flamsteed, and did not leave Newton altogether unscathed. Schroeter had perhaps the best of it. His mountains, twenty or twenty-three miles high on the surface of Venus, may be a myth, but there is no doubt that his measure of the length of her day, $23^h\ 21^m$, is somewhat grudgingly accepted by Herschel, while his estimate of the size of Venus, as rather less than the earth, is preferred to Herschel's, who believed he had proved Venus to be a little larger than the earth. At the same time it must be admitted that Herschel had sometimes cause to complain. Writing of one astronomer in 1799, he says, "the same author's account of my double stars is extremely erroneous."

As early as 1777, while toiling at the daily work of

a musician in Bath, Herschel "found that the poles of Mars were distinguished with remarkable luminous spots." He believed that, by observing them carefully, he might secure a key to a knowledge of the planet, and its history, the length of its day, its atmosphere, its seasons. These observations were continued during six or seven years. Sometimes he saw a well-marked lucid spot on Mars: "it is its south pole, for it remains in the same place, while the dark equatorial spots perform their constant gyrations: it is nearly circular." It was not only circular; "it was very brilliant and white." At other times he saw also another "lucid spot" at the planet's north pole. Occasionally both spots were seen, but the one was "thicker," or "much thicker," than the other, while the thinner was, or seemed to be, longer. After six years of watching he writes, "The white polar spot increases in size; it is very luminous." The conclusions he drew from these notes in his journal, and from his calculations to ascertain the seasons on Mars, must have been listened to by those who first heard them read as if they were a page or two from a romance by Fielding or Smollett. We give them in Herschel's own words.

"The analogy between Mars and the earth is, perhaps, by far the greatest in the whole solar system. . . . If then we find that the globe we inhabit has its polar regions frozen and covered with mountains of ice and snow, that only partly melt when alternately exposed to the sun, I may well be permitted to surmise that the same causes may probably have the same effect on the globe of Mars; that the bright polar spots are owing to the vivid reflection of light from frozen regions; and that the reduction of those spots is to be

ascribed to their being exposed to the sun. In the year 1781 the south polar spot was extremely large, which we might well expect, since that pole had but lately been involved in a whole twelvemonth's darkness and absence of the sun; but in 1783 I found it considerably smaller than before, and it decreased continually from the 20th of May till about the middle of September, when it seemed to be at a stand. During this last period the south pole had already been above eight months enjoying the benefit of summer, and still continued to receive the sunbeams; though, towards the latter end, in such an oblique direction as to be but little benefited by them. On the other hand, in the year 1781, the north polar spot, which had then been its twelvemonth in the sunshine, and was but lately returning to darkness, appeared small, though undoubtedly increasing in size." The length of the year in Mars is nearly two of our years, and the distance from us varies from about 230 to 50 millions of miles.

Astronomers, previous to Herschel's time, had found that Mars was surrounded by an atmosphere like the earth. One of them, Cassini, seems to have suspected the existence of an atmosphere of great density, and rising to a height of about 70,000 miles above the planet's surface.[1] Herschel used the same means as Cassini to determine the height of the atmosphere of Mars by watching the fading or going out of starlight, when a star came up to its limb. At a distance of 30,000 miles there was no indication of an atmosphere. "It appears, however, that the planet is not without a

[1] Thirty-six semi-diameters of the planet. The atmosphere of the earth is now supposed to be about 500 miles in height.

considerable atmosphere. For besides the permanent spots on its surface, I have often noticed," he says, "occasional changes of partial bright belts and also once a darkish one in a pretty high latitude. And these alterations we can hardly ascribe to any other cause than the variable disposition of clouds and vapours floating in the atmosphere of that planet." From the fact that the dark belts or spots and the red colour of Mars manifestly belong to the surface of the planet, we may accept Herschel's idea "that its inhabitants probably enjoy a situation in many respects similar to ours." It has been shown in our own day that the vapour of water, and with that we may associate clouds, is present in the atmosphere of Mars. But there is reason to believe that the atmosphere of Mars is comparatively rare.

Jupiter was not one of the planets from which Herschel reaped an ungathered harvest. The field had been so thoroughly worked by others in searching for a method of easily discovering the longitude at sea, that it does not seem to have presented the same attractions to him as other planets did. A paper which he wrote on Jupiter in 1797—and he wrote no other—gives many curious quotations from his journal regarding the planet and its satellites. So minute are the discoveries made of change of colour and apparent size of the satellites that if the Red spot, detected on the planet in 1878, had been visible in his day, he could scarcely have failed to see it. The bands or belts on the body of the planet, the white and dark spots they showed, the length of day they indicated, and the rotation of the four satellites round their primary were the principal points attended to by

him. The results he arrived at were very near the reality.

Time of rotation of Jupiter on his axis[1]—

	Herschel. H. M. S.
	9 55 49

Time of revolution in its orbit of—

	D. H. M.	D. H. M. S.
First satellite . . .	1 18 26·6	1 18 27 34
Second satellite . . .	3 18 17·9	3 13 13 42
Third satellite . . .	7 3 59·6	7 3 42 33
Fourth satellite . . .	16 18 5·1	16 16 32 11

If the white spots on the belts were connected with drifting masses in Jupiter's atmosphere, they would drift as well as rotate. Herschel was aware of this, and, since his day, the amount of drift has been estimated at 270 miles an hour in the same direction as the rotation. In other words, they would take 42 days to go round the planet from this cause alone. Herschel was also persuaded that the four satellites revolve on their axes in the same period as they revolve round Jupiter, resembling in this respect our moon. Laplace was disposed to accept this conclusion.[2]

For more than a century and a half the planet Saturn had been the object and, it may be said, the despair of every astronomer's curiosity, mainly in consequence of the ring which the telescope had shown it to possess, and the singular shapes the ring was found to assume. Five moons were also discovered to be circling round the planet, and

[1] The great red spot gives 9 h. 55 m. 34 s.

[2] *System of the World*, Bk. I. chs. viii. vii.

Messier, viewing the planet in 1766 with what he calls "an achromatic reflector of 10 feet 7 inches focus," "perceived on his globe two darkish belts, extremely faint and difficult to be discerned, directed, however, in a right line parallel to the longest diameter of the ring."[1] However, till Herschel applied his 40-feet reflector to its system, discovery may be said to have reached its limits. To "the liberal support, whereby our most benevolent King has enabled his humble astronomer to complete the arduous undertaking of constructing this instrument," Herschel writes, was due the discovery of other two moons or satellites, a fuller knowledge of the nature of the ring, and, in short, a new era in our knowledge of that wonderful system. An object so engaging drew Herschel's attention as early as the spring of 1774, long before he was known to fame. On the 17th of March that year, with a 5½-feet reflector, he saw the ring "reduced to a very minute line," and the planet looking like a ball with a knitting-needle projecting through it on both sides. About a fortnight after, the ends of this axis had vanished, and a dark band or shadow crossed the planet's equator from side to side. In the following year he saw the ring gradually open out, with a "dark zone contained between two concentric circles," as if there were two rings with an open space between them. For ten years he continued watching the planet with telescopes of various powers, suspicious that it had not told astronomers all the story of its ring and satellites. The ten years' watch lengthened out to twenty, and the twenty to thirty or more, but this eager watcher still kept guard, ready to take advan-

[1] *Phil. Trans.*, 1769., vol. lix. p. 459.

tage of the slightest lifting of the curtain which concealed a world of wonders from view.

As soon as his great mirror was finished, he turned it on Saturn, and "the very first moment he saw the planet, on August 28, 1789," he was presented with a view of six of its satellites, "in such a situation and so bright as rendered it impossible to mistake them or not to see them." Five of these satellites had been known for more than a century: a sixth was thus added. Constantly continuing his watch on the planet, he was rewarded, three weeks after, with discovering a seventh so close to the planet that the telescopes, previously in use, had failed to find it.[1] Even in his great mirror "it appeared no bigger than a very small lucid point," and it lies so near the planet and its ring that "except in very fine weather, it cannot easily be seen well enough to take its place with accuracy." But he learned from experience, and taught others the lesson, that it is easier to find a small body which has been once seen, and whose place has been marked, than to detect it for the first time amid a crowd of other heavenly bodies.[2] The heavens teach wisdom even in the littlest things, but the lessons they teach are sometimes forgotten as soon as learned. He found also that the time of a sidereal revolution round the planet is 22 hours, 37 minutes, 22 seconds. Both it and the other moon he discovered revolve so near and so parallel to the ring, that he had "repeatedly seen

[1] One discovered by Huyghens in 1655, and four by Cassini in 1671 and onwards.

[2] Compare the ease with which observers detected the small companion of Sirius, and the "crape" ring of Saturn after they were once detected (Ball, *Story of the Heavens*, p. 387).

them run along its very minute arms" at the rate of 9 or 10 miles a second! He was looking from Windsor across a gulf in space about nine hundred millions of miles in width. It was a romance of the heavens—one of many.

On ascertaining that his great telescope was not required for these observations on the ring and moons of Saturn, he "made ten new object specula and fourteen small plain ones for his 7-feet reflector, having already found that the maximum of distinctness might be much easier obtained than where large apertures are concerned." During his long-continued watch of Saturn he saw sometimes a northern belt on the body of the planet, sometimes two belts at the equator. In a couple of days the entry in his journal became "a bright belt over a dark one"; and, nine days later, "one dark and one very faint white belt." The last entry he quotes in 1790 is, "The bright belt close to the ring and two dark equatorial belts." These belts would be about one hundred thousand miles in length: what were they? Similar belts or bands had long been seen and studied on the planet Jupiter. It was agreed among observers that they were probably due to cloudy masses floating in Jupiter's atmosphere. If the same explanation hold for the belts of Saturn, the changes, seen on them by Herschel, would be explained by "a very considerable atmosphere," in which they take place. He not only adopted this conclusion, but confirmed it by another observation. When the two nearest of the moons—the two he discovered in 1789—came, in their progress round the planet, to the edge of the disc, they did not disappear at once, but continued "to

hang to the disk a long while before they would vanish." The seventh or innermost (Mimas) thus hung on the disc for twenty minutes, and the sixth for fourteen or fifteen. Had there been no atmosphere, both of the moons would have been at once hid behind the planet. This takes place when a star comes up to our moon, and vanishes behind it. The star is seen to go out at once; and the conclusion drawn is that this could not happen unless there were no atmosphere or very little of it in the moon to keep the star in sight for us after it had really vanished. Our atmosphere gives us twilight, morning and evening, and enables us to see the sun some minutes before he rises, and for as long after he has set. Ultimately Herschel perceived a quintuple belt, two dark and three bright, on Saturn. Sometimes also he noticed a whitish light at the poles similar to the polar spots on Mars, and due, he believed, to the same cause. But what these belts really are is a problem still unsolved. The vast body of Saturn is lighter than the same volume of water, and would float in it like cork. Our earth is about five times heavier than a globe of water of the same size, and would sink in water like lead. Whether Saturn is still a heated mass, slowly cooling down, and these clouds arise from streams of gas given off, remain problems for the future to solve.

With improved mirrors and a less powerful telescope, he watched the movements and changes of the ring. Between 1790 and 1806 he wrote seven papers for the Royal Society on Saturn and his system. Slowly he came to the conclusion, which he dismissed at first as improbable, that the ring was not single, but double, with a gulf twenty-five hundred miles [1680] in

width between the two parts.[1] The black disc or belt was not in the middle of the ring's breadth. "It is a zone of considerable breadth," which was always seen permanently in the same place. As it was not, what some seem to have supposed, the shadow of a vast range of mountains on the ring's surface, he resolved to wait till the planet came into a position which would enable him to see the stars through the black belt, if it really were a division in the ring, a window, as it were, through which he could look out into space beyond. He does not appear to have been successful in this quest, and it has not been done by others. That there were two unequal rings,[2] separated by this black line, he was satisfied. They were bright rings, but the inner was the brighter of the two. Near the outer edge of the outer ring, he observed and figured "a black list," fainter than the dividing gulf. He did not consider it a division in the outer ring, but it is now a recognised feature, traceable all round. Herschel also

[1] The dimensions of Saturn and his rings are, according to Proctor (*Encyc. Brit.*, "Astronomy," p. 783)—

Diameter of the planet . . .	70,136 miles.
Between planet and "crape" ring .	9,760 ,,
Breadth of "crape" ring . .	8,660 ,,
,, of inner bright ring . .	17,605 ,,
,, of division between bright rings	1,680 ,,
,, of outer bright ring . .	9,625 ,,

The diameter of the ring system is thus about 165,000 miles. Herschel made it about (204,883) 205,000 miles in diameter. He believed that the breadth of the ring is to the space between the ring and the planet as 5 to 4 (*Phil. Trans.*, 1806, p. 463). If the "crape" be left out of account in measuring the ring, the proportion is about 5 to 3·2 (*Phil. Trans.* for 1792). He estimates the vacant space between the outer and inner rings at nearly 2513 miles.

[2] In the proportion of 805 to 280, while the space between was reckoned 115.

saw the edge of the ring as a thin rim of light, and, from some spots seen on it, inferred that it rotated round the planet in 10 hours, 32 minutes, 15 seconds. The planet itself revolves in 10 hours, 14 minutes, 23 seconds.

Highly interesting was the story thus told by the planet; but Herschel wrung from it other details. He suspected that an eighth satellite existed, but it was reserved for others to discover an eighth, and, it is now said, a ninth, at great distances from the planet. But the rings continued to be a puzzle, which baffled solution. He observed lucid points, different from the satellites, coming between the ring and his eye, and moving along it in their orbits. If they were not satellites, what were they? He was not mistaken in "the frequent appearance of protuberant and lucid points on the arms of the ring of Saturn." They were realities, not illusions, not an enchantment lent by the vast distance at which he saw them. "Many of these bright points," he writes, "were completely accounted for by the calculated places of the satellites"; but there were many more which remained inexplicable. He could not entertain the idea that these points "would denote immense mountains of elevated surface." He rather inclined to the belief that the ring was in a state of rotation round the planet, and that one at least of the shining spots might be a moon bedded in or somehow connected with the ring, floating, it might be, in a fluid like water, or running in "a notch, groove or division of the ring to suffer the satellite to pass along." He was perhaps not far from the truth in these romantic imaginings. But the light of the ring is generally brighter than that of the planet, and he even imagined that the shining spots

may owe "their existence to inherent fires acting with great violence." "Nay, we have pretty good reason to believe," he said, "that probably all the planets emit light in some degree; for the illumination which remains on the moon in a total eclipse cannot be entirely ascribed to the light which may reach it by the refraction of the earth's atmosphere." This idea is not borne out by recent observations.

The first two papers Herschel wrote on Saturn, containing the record of more than fourteen years' work, cover nearly ninety pages quarto. Fifty of these pages are merely extracts from his journal, showing the nightly work in which he was engaged, jottings, it may be, all of which required from him time and care, before they could be put down on paper. Here is a specimen of two nights' work, done shortly before midnight:—

"Nov. 7: 22, 9. At the end of the p. arm is a place that is brighter than nearer to the body.

"23, 12. The preceding arm has still the appearance of a small protuberant point towards the south, near the end of the arm.

"Nov. 8: 23;40. There is a protuberant point on the preceding arm besides the 7th sat.; so that at present I cannot tell whether the satellite be the nearest or farthest of them."[1]

By patient, long-continued labour, carried on at all hours of the day and night, is a way prepared for advancing the boundaries of human knowledge, though few are capable of estimating, far less of bearing, the

[1] *Phil. Trans.*, 1790, p. 485 (vol. lxxx.). The seventh and sixth, though last discovered, are nearest to the planet. The longer-known five used to be named in the order of their distance from it.

cost in time and comfort, by the sacrifice of which it is purchased for mankind.

That Herschel was surprised by the brightness of the rings, the greater brightness of the shining points he saw on them, and the yellowish light of the planet, is quite clear. Whether he ever suspected a light or phosphorescence of its own in the system of Saturn, as some observers have now come to think exists, is another matter. But he was on the threshold of that discovery, if discovery it be. He entertained no such idea in 1789 when he classed all the planets "under one general definition, of bodies not luminous in themselves," though two years of farther reflection and observation may have wrought a change in a man of his clear perception and quickness. On another view developed since his day he almost anticipated recent research. He denied that the ring was subdivided by many dark lines into a series of concentric rings, "as has been represented in divers treatises of astronomy." He firmly held to only one division; but he was not far from the modern view, which represents the ring as a mighty mass of revolving satellites, kept in position by the gravity of the planet and the velocity of their rotation round him.

Herschel's memoirs on Saturn cover about one hundred and seventy pages quarto, and the plates that accompany them give a distinct idea of what he saw. By comparing letterpress and plate we may better understand the relation in which he stood to his followers in this field of research and discovery. With one of the new specula, which he ground apparently for the purpose of observing the ring of Saturn more carefully, he got views that he speaks of as "uncommonly

distinct." Of these views he writes: "The outer ring is less bright than the inner ring. The inner ring is very bright close to the dividing space, and at about half its breadth it begins to change colour, gradually growing fainter, and just upon the inner edge it is almost of the colour of the dark part of the quintuple belt."[1] A little after he adds: "The shadow of the ring upon Saturn, on each side, is bent a little southwards, so that the apparent curve it makes departs a little from the ring." Looking at these singular companions of the planet across a gulf eight or nine hundred millions of miles wide, it is not surprising that an astronomer prays for "light, more light," to resolve this puzzle of the bright and the dark. It is only an outline of the ring, at the best, that we can expect to obtain from the most careful drawings. But what Herschel did not suspect or imagine about the ring, it would be natural for him to confound with other features that took a greater hold of his fancy. Of the inner ring he says: "At about half its breadth it begins to change colour," that is, it passes from "very bright" to the darkness of the quintuple belt. Now this was said of the ring as seen and figured in 1794. Compare it with the three rings in the three figures shown in 1792. They are unlike that of 1794. Either the ring had changed, or Herschel was in 1794 looking on two inner rings, a bright or very bright ring, and a dark. This was Professor Bond's discovery in 1850, "a crape ring" half the breadth of the very bright inner ring, between it and the body of the planet. There are thus three well-marked rings in the system of Saturn, a somewhat dark outer, a very

[1] *Phil. Trans.*, 1794, pp. 54, 57.

bright inner, and a "crape" or slate-coloured ring nearer still to the planet. Did Herschel not see and figure all three, only failing to observe the interval between the very bright and the "crape" ring? We can only express our surprise if one so quick of eye, and so careful to observe, ascribed to the bright ring in 1794, what he did not see or delineate on it in 1792, if the "crape" existed then as it exists now.

Fifty years after, Sir John Herschel, when at the Cape of Good Hope, made a careful search for the two moons discovered by his illustrious father. He had all but given it up in despair when, looking for the other five "with the 20-feet reflector," which he took with him to South Africa, "and a polished new mirror, there stood Mr. Sixth! . . . Next night it was kept in view long enough for Saturn to have left it behind by its own motion, had it been a star. . . . So this is *at last* a thing made out," he writes. "As for No. Seven, I have no hope of ever seeing it."

Since Herschel's time the minds of men have become familiar with strings of meteorites, millions of miles in length, through which our earth plunges in its yearly journey round the sun. If they form, or come in time to form, a continuous ring about the sun, one hundred thousand miles in breadth, we may have on a vastly larger scale a parallel to the rings of Saturn. The breadth of the latter is only about one-third of the breadth of one well-known stream of meteors, and their length is not a quarter of a million of miles. If then these rings of the planet are similarly composed of separate masses, great and small, and are not continuous rings, perhaps 250 miles in thickness, a satellite "floating in a fluid like water, or running in a notch,

groove or division of the ring," while it ceases to be a fanciful, becomes also an unnecessary conception.

Such are the main features of the romance of Saturn since Herschel began his study of it one hundred and twenty-five years ago. In the hundred and twenty-five years that preceded, there had also been mystery and romance about the planet and his ring. All the riddles presented by this system have not been yet read, and it is likely that, when improvements in telescopes or observation enable man to read the riddles that face him to-day, they will raise new riddles and give birth to other romances for the amazement or delight of future ages. On one point science is still in doubt. Does the fifth satellite of Saturn, like our moon, always show the same face to the planet, or, in other words, turn on its axis in the same time that it takes to revolve round him? Herschel believed he had proved, or almost proved, that it "turns once on its axis, exactly in the time it performs one revolution round its primary planet."

It was only fitting that the discoverer of Uranus should pay special attention to that planet: but five or six years elapsed before his patient watchfulness was crowned with any success. Unlike Jupiter and Saturn, the light of Uranus is very faint. He does not invite pursuit; he flies from it into darkness: and the light of his moons is fainter still. Herschel suspected, perhaps hoped, that if he searched for satellites he would find them. And so he did. On January 11, 1787, he saw "some very faint stars" near the planet, "whose places he noted down with great care." Next evening two of them were missing. As the haziness, that was about, might have caused their disappearance, he noted

"all the small stars near the planet the 14th, 17th, 18th, 24th of January, and the 4th and 5th of February." On the 7th of February he kept one star in view for nine hours, from six in the evening till three next morning. His journal records that he saw it "faithfully attend its primary planet." On the second night after, he was so satisfied of having caught sight of a second moon, that he delineated on paper what he expected to see the following evening. And he saw in the clear heavens what he sketched sixteen or seventeen hundred million of miles away, "The Georgian Planet, attended by two satellites." Oberon and Titania are the fairy names by which they are now known. "I confess," he adds, "that this scene appeared to me with additional beauty, as the little secondary planets seemed to give a dignity to the primary one, which raises it into a more conspicuous situation among the great bodies of our system. For upwards of five hours I saw them go on together, each pursuing its own track." It was the heroic age of astronomical research. A hero there and a hero here were wrestling with difficulties and winning triumphs in the world of stars. They were men of extraordinary skill and unwearied endurance. It was nearly fifty years after their discovery before the fairies, Oberon and Titania, again condescended to show themselves to a mortal, the son of their discoverer.[1] And it enabled his aunt, then ninety years of age, to write: "These folks would not have called the Herschelian construction useless, if they had seen the struggle, during the years from 1781 to '86, to get a sight of

[1] Holden, *Life and Works of W. H.*, p. 143. But see Caroline's *Memoirs*, pp. 261, 305.

the satellites of the Georgium Sidus, when, after throwing aside the speculum, they stood broad before us."

From observations continued on Uranus for fifteen years, Herschel first suspected, and then became convinced that other satellites besides the two, which he discovered in 1787, attend the planet on its journey round the sun. It was labour of love not lost, or grudgingly given, but the fruits it yielded were Dead Sea apples with a fair outside and rottenness within. He believed he saw other four moons circling round Uranus apparently in an opposite direction to other planets, that is, from east to west, not from west to east. He also suspected that it had a ring round it, or two rings; then he gave up the idea; then he entered in his journal, "When the satellites are best in focus, the suspicion of a ring is the strongest"; and nine months after he adds, "The planet is not round, and I have not much doubt but that it has a ring." He used "successively powers rising from 240 to 2400," more than two years after, "without any suspicion of a ring." A fortnight later he tried magnifying powers of 2400 and 4800. In conclusion he believed in the four new satellites, but gave the ring up. A traveller in unexplored regions of the heavens may thus be as much the victim of a mirage as a wanderer in the thirsty deserts of earth. But a singular thing was observed: these moons of Uranus became invisible when they approached the planet, which those of Jupiter and Saturn never did till the planet got between them and us. What was the reason?

The cause is in the eye of the observer himself. It requires to adapt itself to the light which falls on the

retina. Now "the planet is very faint; and the influence of its feeble light cannot extend far with any degree of equality. This enables us to see the faintest objects, even when they are only a minute or two removed from it. The satellites are very nearly the dimmest objects that can be seen in the heavens; so that they cannot bear any considerable diminution of their light, by a contrast with a more luminous object, without becoming invisible. If then the sphere of illumination of our new planet be limited to 18″ or 20″, we may fully account for the loss of the satellites when they come within its reach; for they have very little light to lose, and lose it pretty suddenly." This view of a weak light extinguishing a weaker, though a commonplace now, received a very poetical interpretation in a paper written by Herschel three years after. "This increased sensibility," he says, "was such, that if a star of the 3rd magnitude came towards the field of view, I found it necessary to withdraw the eye before its entrance, in order not to injure the delicacy of vision acquired by long continuance in the dark. The transit of large stars, unless where none of the 6th or 7th magnitude could be had, has generally been declined in my sweeps, even with the 20-feet telescope. And I remember, that after a considerable sweep with the 40-feet instrument, the appearance of Sirius announced itself, at a great distance, like the dawn of the morning, and came on by degrees, increasing in brightness, till this brilliant star at last entered the field of view of the telescope, with all the splendour of the rising sun, and forced me to take the eye from that beautiful sight." To increase this sensibility of the eye he was on these occasions in the

habit of excluding light from surrounding objects by wearing a black hood.

Herschel was not content with wresting from Uranus this novel part of his story. He continued to watch the planet. Unfortunately, the same success did not crown his efforts to read its history. A great number of observations on imaginary rings and supposed moons, that were found to be stars, or not moons but probably moving, planetary bodies of the asteroid nature, demanded his attention, and deceived his hopes. It was such a tantalising pursuit, that even "the direction of a current of air alone may affect vision." At last he came to the conclusion that no ring, similar to Saturn's, girdles Uranus; but that, certainly, four additional satellites accompany him on his long journey of eighty-four years round the sun. Astronomers who came after his time failed to find these four moons, but, later still, two satellites have been added to the original two discovered by Herschel. One of the additions is suspected to belong to the four he believed he had seen circling round the planet. Of the four recognised satellites the most distant, Oberon, performs its round in 13·46 days, or, as Herschel found, 13 days, 11 hours, 5 minutes, 1½ seconds. Other information, which by careful watching he wrung from Uranus, has been verified or corrected by those who came after him; but to this unwearied observer belongs the credit of showing that the two satellites he discovered, unlike other members of the solar system, revolve in orbits nearly at right angles to the ecliptic, and that their course is retrograde, or from east to west, not direct, that is, from west to east. These were two singular and outstanding

discoveries made by Herschel in the system of Uranus.

The two small planets, Ceres and Pallas, discovered in 1801 and 1807, have strangely given the tooth of envy an opportunity of wounding the good name of Herschel. As he found their discs like those of fixed stars, spurious and not measurable; as they "resembled small stars so much as hardly to be distinguished from them even by very good telescopes," as he imagined them from the haziness he saw around them to be "comets in disguise," he considered planet a misnomer as applied to them, and proposed to call them *asteroids*. Strange to say, the friend of Piazzi and Olbers, who discovered these small bodies, was charged with intending, by the suggestion of this diminutive, to cast a slight on the achievement of his friends, in comparison with his own glory as the discoverer of the great planet, Uranus. A more stupid slander of a most generous heart could scarcely be imagined. He predicted that the association of astronomers which had been formed on the Continent to hunt for more of them would be successful: "Many may soon be discovered," he informed the Royal Society. Two were caught within the next five years, Juno and Vesta, but the "many" foretold by Herschel in 1802 remained an unfulfilled prediction for more than forty years. He himself joined in the hunt, and failed: "I have already made five reviews of the Zodiac without detecting any of these concealed objects." Yet he was slandered as envious of the fame of others who had done what he confessed he had failed in doing,[1] although in 1813 he told Thomas Campbell, the poet, that "there

[1] *Phil. Trans.* for 1802, pp. 228–30.

will be thousands—perhaps thirty thousand more—yet discovered." The discovery of the fourth, called Vesta, he pronounced "an event of such consequence" as to "engage his immediate attention." He called it "a valuable addition to our increasing catalogue of asteroids"; and he spoke of the "celebrated discoverers" as inducing "us to hope that some farther light may soon be thrown upon this new and most interesting branch of astronomy."[1] Dr. Olbers himself wrote to Herschel that Vesta "was not to be distinguished from a fixed star";[2] while Schroeter, the countryman and neighbour of Olbers, had already communicated a paper to the Royal Society in which he said:[3] "Its image was, *without the least difference*, that of a fixed star of the 6th magnitude with an intense radiating light; so that this new planet may with the greatest propriety be called an *asteroid*." That one scientific man should attack, or rather slander, another for giving to these small bodies a scientifically appropriate name, on the ground that he thereby intended to derogate from the credit of his own friends, whom he publicly extolled as "celebrated discoverers," seems incredible. Yet it was done.

By a most ingenious contrivance he managed to obtain approximate values for the diameters of Ceres and Pallas. The former he found to be 161·6 miles; the latter smaller, 147 or 110⅓ miles. So small is Pallas that it would require many thousands equally small to make up a planet no larger than Mercury. The colour of Ceres he found to be "ruddy, but not very deep"; that of Pallas, "milky whitish."

[1] Letter from Dr. Olbers, April 20, 1807.

[2] *Phil. Trans.*, 1807, p. 260. [3] *Phil. Trans.*, May 28, 1807, p. 245.

In 1807 Herschel concluded one of his papers in these words: "I find that out of the sixteen comets which I have examined, fourteen have been without any visible solid body in their centre, and that the other two had a very ill-defined small central light, which might perhaps be called a nucleus, but did not deserve the name of a disk." In the end of September that year a comet was discovered by Mr. Pigott, to which Herschel at once turned his attention in the hope of wresting from it information regarding its nature. By careful observations, continued over five months, he felt himself warranted in claiming for it "a visible, round and well-defined disk," 538 miles in diameter, and "shining in every part of it with equal brightness." He came also to the conclusion "that the body of the comet on its surface is self-luminous, from whatever cause this quality may be derived." He inferred besides that "the changes in the brightness of the small stars, when they are successively immerged in the tail or coma of the comet, or cleared from them, prove evidently, that they are sufficiently dense to obstruct the free passage of star-light." The tail of this comet, three weeks after its discovery, was more than nine millions of miles in length, and Herschel was inclined to think that it "consisted of radiant matter, such as, for instance, the aurora borealis." It was not bifid or split in two, as that of the comet of 1769 had been, but it presented a peculiarity seen also in others of these bodies: "The south-preceding side, in all its length, except towards the end, is very well defined: but the north-following side is everywhere hazy and irregular, especially towards the end; it is also shorter than the south-preceding one, . . . even to the naked eye."

If Herschel had not known this body to be a comet, he would have described its head, as "a very large, brilliant, round nebula, suddenly much brighter in the middle." He says that he would have added, "The centre of it might consist of very small stars." So struck was he with this singular idea that he directed a telescope "with a high power to the comet." He then saw "several small stars shining through the nebulosity of the coma." The terror which once surrounded the appearance of these bodies in the heavens is gone; the awe remains, and, as knowledge increases, the mysteries that attend their birth, their growth, their flight through space, have become greater and more wonderful problems awaiting solution.

CHAPTER XI

HERSCHEL'S ENGLISH HOME

So long as Herschel's house was conducted by his sister Caroline, it could scarcely be called an English home. To all intents and purposes it was a German household, ruled by a German mistress, and conducted according to German ways. When he married the widow of a London merchant, Mrs. Pitt, his sister, who had been for some time kept unusually busy with papers and calculations, wrote, as she was withdrawing from this household management, "It may easily be supposed that I must have been fully employed (besides minding the heavens) to prepare everything as well as I could against the time I was to give up the place of a housekeeper, which was the eighth of May, 1788." She continued to mind the heavens; but she had a good deal also to do with the earth.

Of the lady to whom Herschel was married, of himself, and of his sister we have excellent word-pictures, drawn by Miss Burney and her father. Caroline, who for fourteen years had devoted her life to her brother's studies, and who continued to show the same devotion for sixty more, though resigning the post of housekeeper, remained to help him in his pursuits and to watch over his health. Reading the brief entries in her diary, we cannot help concluding that in many

respects she was the real, but not the nominal head of that centre of activity and discovery. When Dr. Burney called on Herschel in 1798, ten years after his marriage with Mrs. Pitt, to consult him about his great poem on astronomy and astronomers, he was surprised to find Mrs. Herschel, and not her sister-in-law Caroline, at the head of the table, while a merry little son of six, afterwards Sir John Herschel, amused him and the rest of the company. Dr. Burney did not know that his friend William Herschel was married. Even in 1817, another visitor, Dr. Niemeyer, was equally ignorant. These are proofs of the gentle, retiring nature of the wife, to which Herschel's friends bear witness, and of the overshadowing celebrity to which his sister had attained. From all quarters we learn that it was as pleasant a home as it was a famous observatory.

Miss Burney, the famous authoress of *Evelina*, who accepted the post of assistant wardrobe keeper to the Queen in Windsor Castle at £200 a year, when she might have earned ten times that amount by her pen, and retained her independence besides, may possibly have had a fellow-feeling with Herschel, who was condemned, as she was, to bear heavy burdens from the etiquette of a court. Her picture of him is every way delightful; his wife comes in for a briefer notice and for less praise. At a tea-party and concert in Windsor she met them both, five months after their marriage. "Two young ladies were to perform," she says, "in a little concert. Dr. Herschel was there, and accompanied them very sweetly on the violin; his new-married wife was with him, and his sister. His wife seems good-natured; she was rich, too! and astro-

nomers are as able as other men to discern that gold can glitter as well as stars."[1] There is a falling-off here from the enthusiasm of former days: a great falling-off.

Two years previous Miss Burney described Herschel, or her first impressions of him, in much more glowing terms. "In the evening Mr. Herschel came to tea. I had once seen that very extraordinary man at Mrs. De Luc's, but was happy to see him again, for he has not more fame to awaken curiosity than sense and modesty to gratify it. He is perfectly unassuming, yet openly happy, and happy in the success of those studies which would render a mind less excellently formed presumptuous and arrogant.

"The King has not a happier subject than this man, who owes it wholly to His Majesty that he is not wretched; for such was his eagerness to quit all other pursuits to follow astronomy solely, that he was in danger of ruin, when his talents and great and uncommon genius attracted the King's patronage. He has now not only his pension, which gives him the felicity of devoting all his time to his darling study, but he is indulged in license from the King to make a telescope according to his new ideas and discoveries, that is, to have no cost spared in its construction, and is wholly to be paid for by His Majesty.

"This seems to have made him happier even than the pension, as it enables him to put in execution all his wonderful projects, from which his expectations of future discoveries are so sanguine as to make his present existence a state of almost perfect enjoyment.

"He seems a man without a wish that has its object

[1] October 3, 1788.

in the terrestrial globe. At night Mr. Herschel, by the King's command, came to exhibit to His Majesty and the Royal Family the new comet lately discovered by his sister, Miss Herschel; and while I was playing at piquet with Mrs. Schwellenberg, the Princess Augusta came into the room, and asked her if she chose to go into the garden and look at it. She declined the offer, and the Princess then made it to me. I was glad to accept it for all sorts of reasons. We found him at his telescope. The comet was very small, and had nothing grand or striking in its appearance; but it is the first lady's comet, and I was very desirous to see it. Mr. Herschel then shewed me some of his new discovered universes, with all the good humour with which he would have taken the same trouble for a brother or a sister astronomer; there is no possibility of admiring his genius more than his gentleness."

Of these four paragraphs the first and the last show undisguised, genuine admiration of this hero of the stars by a heroine of the pen, "for all sorts of reasons."[1] It was the queen of literature crowning the king and high priest of the stars with the laurel wreath of a world's homage. Perhaps it was more than this, different though the ages of the king and queen were. But the second of the four paragraphs is of a different nature. It hints at dangers and difficulties, which do not square with Caroline Herschel's *Memoirs*. They may be explained by Miss Burney's knowledge of the

[1] Miss Burney tells the story of love's progress in her novel of *Evelina*, written some time before: "How rapid was then my Evelina's progress through those regions of fancy and passion, whither her new guide conducted her! She saw Lord Orville at a ball—and he was *the most amiabl of men!* She met him again at another—and *he had every virtue under heaven!*" (*Evelina*, ii. 149).

talk and whispers among the King's equerries at Windsor Castle. That a man should be "wretched" and "in danger of ruin," who had established himself at Bath and was making a large income there,[1] points to something more serious than she could realise or wished to repeat. Probably the equerries knew about it, and, without revealing secrets, gave her an indistinct idea that something was or had been seriously wrong.

At the very end of 1786, Miss Burney is still in raptures: "This morning my dear father carried me to Dr. Herschel. That great and very extraordinary man received us almost with open arms. He is very fond of my father, who is one of the council of the Royal Society this year, as well as himself." The fondness and the friendship must have been commonplace, when, twelve years later, Dr. Burney did not know that Dr. Herschel had been married for ten years, and was the father of a son six years of age. But the young lady's admiration knows no abatement. Nine months after, it rises to, "Dr. Herschel is a delightful man; so unassuming with his great knowledge, so willing to dispense it to the ignorant, and so cheerful and easy in his general manners that, were he no genius, it would be impossible not to remark him as a pleasing and sensible man." Miss Burney's picture is not over-coloured, according to the evidence of other eye-witnesses. She was then thirty-four years of age, and seven years after married a French emigrant, without fortune and without prospects. Enthusiasm such as she showed for William Herschel,

[1] *Memoirs*, p. 321, "Was called from his lucrative employment at Bath."

and pardonably showed, may have been akin to a warmer feeling; but his marriage for money, partly at least, somewhat cooled her raptures, or her hopes.

Dr. Burney has also presented the world with word-pictures of himself and Herschel, which are full of life and amusement. As time went on, he was fired with the ambition of distinguishing himself in poetry as well as music. He believed he had wing-power sufficient to soar to heights of poetry as high as Newton or Herschel reached in prose. He proposed in fact to write a Newtoniad and a Herscheliad for the enlightenment of future ages. He made no secret of his purpose; his daughters encouraged him to undertake the work; Herschel was consulted, was flattered, was persuaded or cajoled. The King, the Queen, the Princesses heard of the great work; the Court, of course, whatever some people of sense may have thought or said, echoed the wishes and praises of their superiors, and the poet proceeded, amidst applause, to complete his *Poetical History of Astronomy*. It was the age of didactic poems. Darwin's *Botanic Garden* had been a success, and parts of it were so written that they deserved and won the applause of intelligent readers. Probably Dr. Burney imagined that astronomy, which was then filling the world with wonder, was an equally good field for a great poem. He certainly believed that it was a book he was competent to write: but, while he was convinced of his ability to ascend to the heights of Parnassus, he had doubts of his knowledge of the science. To solve these doubts an interview with Herschel was necessary. The story then proceeds, September 28, 1798.

"I drove through Slough in order to ask at Dr. Herschel's door when my visit would be least inconvenient to him—that night or next morning. The good soul was at dinner, but came to the door himself to press me to alight immediately, and partake of his family repast: and this he did so heartily that I could not resist. . . . I expected (not knowing that Herschel was married) only to have found Miss Herschel; but there was a very old lady, the mother, I believe, of Mrs. Herschel, who was at the head of the table herself, and a Scots lady (a Miss Wilson, daughter of Dr. Wilson of Glasgow, an eminent astronomer), Miss Herschel, and a little boy. They rejoiced at the accident, which had brought me there, and hoped I would send my carriage away and take a bed with them.

"We soon grew acquainted—I mean the ladies and I—and before dinner was over we seemed old friends just met after a long absence. Mrs. Herschel is sensible, good-humoured, unpretending, and well-bred; Miss Herschel all shyness and virgin modesty; the Scots lady sensible and harmless; and the little boy entertaining, promising, and comical. Herschel, you know, and everybody knows, is one of the most pleasing and well-bred natural characters of the present age, as well as the greatest astronomer."

"The shyness and virgin modesty" of little Miss Herschel, at the youthful age of forty-eight, are overdone in this word-picture by Dr. Burney. Could we have got her views of their visitor's flattery and folly, they would perhaps have been an amusing addition to the fund of drollery and acidity, with which her recollections are pleasantly flavoured. And

they would have been to the point. When Dr. Burney made Herschel aware of his purpose in calling, the latter insisted on the trunk being unpacked, the poem produced, and the reading finished then and there. What the poet knew would be the work of a week or a month, if the book had been finished, the astronomer hoped to get out of the road as speedily as he would an ordinary observation on a starry night. He found himself buttonholed to instalments that spread over many months, and seem to have grown very captivating, though he must have soon seen that, if his was the sword of fame, Burney considered his tongue as the more important trumpet, that would blow that fame abroad to all time. But the situation was full of surprises. "He made a discovery to me," Dr. Burney goes on to say, "which had I known it sooner, would have overset me, and prevented my reading any part of my work. He said that he had almost always had an aversion to poetry, which he regarded as the arrangement of fine words, without any useful meaning or adherence to truth; but that when truth and science were united to these fine words, he liked poetry very well." This is rather an odd confession to come from a man whose sister tells us, "He composed glees, catches, etc., for such voices as he could secure, as it was not easy to find a singer to take the place of Miss Linley."[1] However, Dr. Burney managed to persuade him that in his didactic poem fine words were united to science and truth. The astronomer called on the poet in town, lived in his house, and

[1] Was the song referred to on p. 321 of the *Memoirs*, "In thee I bear so dear a part," his own? It "was going to be published by desire."

gave audience to his verses: "Herschel was so humble as to confess that I knew more of the history of astronomy than he did, and had surprised him with the mass of information I had got together. . . . He thanked me for the entertainment and instruction I had given him. 'Can anything be grander?' and all this before he knows a word of what I have said of himself — all his discoveries, as you may remember, being kept back for the twelfth and last book."

After an interval of seven months and more, a long story follows of Herschel's patience and good humour under repeated doses of poetry, conceit, and undue self-importance from Dr. Burney. The latter's letter to his daughter, then Madame D'Arblay, is dated, "Slough, *Monday morning*, July 22, 1799, in bed at Dr. Herschel's, half-past five, where I can neither sleep nor lie idle," and runs thus: "I believe I told you on Friday that I was going to finish the perusal of my astronomical verses to the great astronomer on Saturday." Burney had already read to him the Newtoniad, and other pieces. He was now come to the Herscheliad, about twenty years too soon, for the astronomer had not reached the height of his fame in 1799. "After tea Herschel proposed that we two should retire into a quiet room in order to resume the perusal of my work, in which no progress has been made since last December. The evening was finished very cheerfully; and we went to our bowers not much out of humour with each other or the world." Much more follows, revealing the self-complacency and conceit of the man, along with the modesty and retiring nature of Herschel. There were

only two men on the terrace or in the Castle concert-room that evening, the King and Dr. Burney; and the important subject talked of was Dr. Burney's poem.

Herschel's friendship with Dr. Wilson,[1] the Professor of Astronomy in Glasgow University, was probably the reason of repeated visits paid by him to Scotland. Of the first of these visits no notice is taken by his sister, a somewhat singular omission. It was paid in the summer of 1792. The second known visit was made eighteen years after, is briefly referred to by his sister, and is confounded by his biographers with that of 1792. It took place in 1810. A third visit, obscurely hinted at by his sister, took place the following year. In a paper read to the Royal Society in 1812, he mentions an observation of the comet of 1811 made by him at Glasgow, and records another which he made at Alnwick on his way south, some weeks later. That Glasgow may have been to Herschel a place of summer pilgrimage more frequently than on these three visits seems not improbable. His friendship with the Wilsons and their families, like that with Dr. Watson, was close and long continued, the friendship of worthy men, holding each other in the highest esteem. As he visited Dr. Watson at Bath and Dawlish, so he appears to have visited the Wilsons at Glasgow. At any rate we know that he "was generally from home" in summer.

When Herschel was in Scotland in the summer of 1792, he was accompanied by a Russian friend, General Komarzewsky. So intimate were the two

[1] Alexander Wilson was Professor of Astronomy from 1760 to 1784; his son Patrick from 1784 to 1799.

that the General "used to say to Herschel, Why does not he (meaning King George III.) make you Duke of Slough?" Probably his sister thought the same, but the pardonable flattery created a bond between them, which she does not seem ever to have forgotten. On reaching Glasgow, Herschel found a pleasant surprise awaiting him and his friend, as new as it was unexpected. Both of them were to be honoured with the freedom of the city. Glasgow was then a town, where salmon-fishers dried their nets on that busy centre of trade, the Broomielaw, and was inhabited by not more than a tenth of its present population; but its magistrates were far-seeing men, who crowned their city with honour when they formally entered on their Burgess Roll the name of William Herschel. Their Council Records contain the following:[1]—

"GLASGOW, 19*th June* 1792.

"The said day Dr. William Herschel, Astronomer, and General Homarseuski are unanimously admitted honorary Burgesses and Guild Brethren of this City."

An Edinburgh newspaper[2] recorded the homage thus paid to science by the merchant city of the west, but the Edinburgh Town Council, neither then nor subsequently, followed the example so honourably set by Glasgow.

[1] I am indebted for this extract to the kindness of Sir James Marwick, the Town Clerk of Glasgow.

There appears to be some doubt about the spelling of the Russian name in the Council Record.

[2] *Edinburgh Courant*, June 28, 1792.

Another visit paid by Herschel was to Paris at the commencement of the shortlived peace of Amiens in 1801. From the brief notes preserved in his sister's *Memoirs* it appears that, on July 13, "my brother, Mrs. H., my nephew John, and Miss Baldwin left Slough to go to Paris." The next entry is, "Aug. 25th. —All returned with my nephew dangerously ill. Going daily for some hours to work at the Observatory, and to receive visitors and letters, had not hastened my recovery, for it required no less than seven months before I could be without the attendance of Dr. Pope." During these weeks of holiday in France, Herschel had opportunities of renewing or strengthening the friendly feelings with which the astronomers of that country, during an age of great hostility between the two nations, regarded the labours of their English brethren. They had shown their esteem for him in particular by choosing him as a member of the Institute, one of the highest honours that could be bestowed on a man of science. But his visit was made more remarkable by an interview with Napoleon Buonaparte, who was then First Consul, and afterwards Emperor. Twelve years later he gave an account of it to Thomas Campbell, the poet, who met him at Brighton, and thus records the story:[1]—

"I was anxious to get from him as many particulars as I could about his interview with Buonaparte. The latter, it was reported, had astonished him by his astronomical knowledge.

"'No,' he said; 'the First Consul did surprise me by his quickness and versatility on all subjects; but in

[1] Beattie's *Life of Campbell*, ii. 234, 235, 239.

science he seemed to know little more than any well-educated gentleman, and of astronomy much less for instance than our own King. His general air,' he said, 'was something like affecting to know more than he did know.' He was high and tried to be great with Herschel, I suppose, without success; and 'I remarked,' said the astronomer, 'his hypocrisy in concluding the conversation on astronomy by observing how all these glorious views gave proofs of an Almighty Wisdom.' I asked him if he thought the system of Laplace to be quite certain, with regard to the total security of the planetary system from the effects of gravitation losing its present balance? He said, No; he thought by no means that the universe was secured from the chance of sudden losses of parts."

It is unfortunate that no other record exists of the estimate formed of Napoleon by Herschel. Campbell may have imported into the astronomer's words turns of thought which he never meant to convey, and a man is sometimes more free of speech in conversation than he would be in print. An interviewer, as modern journalism has proved, may, even without knowing it, give an unhappy twist to a man's words and thoughts. Assuming, however, that the poet's report is strictly correct, and remembering that the great bitterness of Herschel's life sprang from a French victory, unforgettable by him or his relations, his words must be received with a discount unavoidable in the circumstances. Both poet and astronomer show their feelings, perhaps, by the use of the long obsolete title "First Consul" instead of the better known "Emperor," and it ought never to have been

said that Napoleon, a trained and experienced officer of artillery, a member of the mathematical section of the Institute of France, and the founder of the Egyptian Institute, knew little more of science than any well-educated gentleman. To compare his knowledge of astronomy with that of George III. is unfair. If Herschel meant nothing more than what the King learned from him and Mainburg and Bevis during half a century, of the ways and methods of observing, it may be perfectly true, and yet may have been such as Napoleon, with his natural quickness and his knowledge of mathematics, could have picked up in an hour or two. But a comparison of the two men — one doing little more than signing his name, the other leading mighty armies, fighting terrible battles, and ruling almost a whole continent —seems exceedingly absurd, from an intellectual point of view. Nor should it be forgotten that Napoleon, by taking the learned men of France to Egypt with him, entertaining them at his table on shipboard, and protecting them in their researches, laid the foundation of a new science, which has filled mankind with wonder — the languages and records of the ancient worlds of Egypt and Assyria. To say that he affected to know more than he did know was, if true, a justifiable pretence in a man ruling over many nations, and absorbed in multitudinous details. But to charge him with hypocrisy for expressing his views on Almighty Wisdom is not creditable to either poet or astronomer. If Herschel conversed with him by means of an interpreter, the latter may have done, and possibly would do, injustice to the Emperor, perhaps to the astronomer also. But

it is not likely that Napoleon, who wrote to Laplace about his great works, and was on intimate terms with the greatest minds of France, would descend to parade knowledge he did not possess, or indulge in a hypocrisy that was altogether out of place. Even his biographer writes, "The impression left upon Campbell's mind by this conversation appears to have been a little too strong."

Far more pleasant is the view given by Campbell of the astronomer himself. "I spent all Sunday with him and his family," he says. "His simplicity, his kindness, his anecdotes, his readiness to explain—and make perfectly perspicuous too—his own sublime conceptions of the universe are indescribably charming. He is seventy-six, but fresh and stout; and there he sat, nearest the door, at his friend's house, alternately smiling at a joke, or contentedly sitting without share or notice in the conversation. Any train of conversation he follows implicitly; anything you ask he labours with a sort of boyish earnestness to explain—a great, simple, good old man." The impression made on Campbell's mind is summed up in these words: "I really and unfeignedly felt as if I had been conversing with a supernatural intelligence. . . . After leaving Herschel I felt elevated and overcome; and have in writing to you made only this memorandum of some of the most interesting moments of my life."

A German writer, who paid a visit to Herschel at Slough a few years afterwards, has left an equally pleasant picture of the astronomer-sage.

"While we were standing by this machine (the great telescope), which we more admired than com-

prehended, its master appeared, a cheerful old man, aged eighty-one. How unassumingly did he make his communications! How lightly did he ascend the steps to the gallery! With what calm pleasure did he seem to enjoy the success of his efforts in life! All accounts from his native country appeared to please him, although the German language had become somewhat less familiar to his ear. After a short conversation, we took our leave, charged with friendly greetings to all beyond the sea, who might still remember him.

"Herschel is unmarried, but his sister Caroline resides with him, not only as a superintendent of his household, and support of his old age, but also as a partaker of his studies. She has been his constant assistant in his labours, and has made some discoveries herself, among which were five comets in the years 1786, 1791, a dissertation on which she laid before the Royal Society. Both of them enjoy the love and esteem of all that approach them.

"Herschel's earthly labour is now, I presume, at an end, and the time cannot be far distant when we shall be able to say of him,

> 'Candidus consuetum miratur limen Olympi,
> Sub pedibusque,—nubes et sidera videt.'"

In terms of his appointment as King's Astronomer, Herschel was bound to receive visitors sent from Windsor Castle, and to explain to them his instruments, as well as to act the part of showman of the heavens. Probably this dangling at the heels of titled nothings brought him money from the sale of telescopes, but it was a tax on his time and strength, which his sister

saw and dreaded from the first. "I know how wretched and feverish one feels after two or three nights' waking," Caroline writes of her own all-night vigils. With a woman's quickness for those she loves, she sometimes managed to shield her brother, wearied, like her, with an all-night sitting, from these thoughtless callers. "In my way into the garden," she writes, as far back as 1797, "I was met and detained by Lord S. and another gentleman, who came to see my brother and his telescopes. By way of preventing too long an interruption, I told the gentlemen that I had just found a comet, and wanted to settle its place. I pointed it out to them, and after having seen it they took their leave." But she could not always thus act the part of guardian angel. On October 4, 1806, "two parties from the Castle came to see the comet," observed two days before, "and during the whole month my brother had not an evening to himself. . . . It has ever been my opinion that on the 14th of October his nerves received a shock of which he never got the better afterwards; for on that day (in particular) he had hardly dismissed his troop of men," assisting him in the laborious work of polishing the 40-feet mirror, "when visitors assembled, and from the time it was dark till past midnight he was on the grass-plot surrounded by between fifty and sixty persons, without having had time for putting on proper clothing, or for the least nourishment passing his lips. Among the company, I remember, were the Duke of Sussex, Prince Galitzin, Lord Darnley, a number of officers, Admiral Boston, and some ladies." The picture is outlined with a clearness nothing but strong feeling could inspire; the strain was manifestly

too great, and it was tearing down his enfeebled frame. For sixteen years the battle continued; the phases of it are recorded by his biographer, and little remains but to trace in her words, how year after year saw his strength declining and the flame of life dying out. At the same time it is difficult to understand how Herschel and his wife allowed this process of painful decay to go forward unchecked. He did not require thus to die in harness actually by inches. Both of them were wealthy;[1] and though he had resigned office, it is not probable that his pension would have been withdrawn. But the story of fading strength is told in words that cannot be explained away.

"When all hopes for the return of vigour and strength necessary for resuming the unfinished task of polishing the great mirror was gone, all cheerfulness and spirits had also forsaken him, and his temper was changed from the sweetest almost to a pettish one; and for that reason I was obliged to refrain from troubling him with any questions, though ever so necessary, for fear of irritating or fatiguing him." Want of room, the refusal of funds to meet expenses, the great telescope "nearly fallen into decay almost in all its parts," "every nerve of the dear man unstrung by over-exertion," may well send a thrill of sympathetic sorrow through every reader of the story. Neither Brighton nor Bath, nor summer visits to Edinburgh or Glasgow could restore the lost tone: "A farther attempt at leaving the work complete became impossible." How sorrowful the entries for more than a

[1] His personal effects are set down in his will at £6000, and he left £25,000 more in 3 per cent. Reduced Annuities to his son, besides other large legacies.

twelvemonth after! "My brother not well," "his life despaired of," "permitted to see him, but only for two or three minutes"! And in this time of distress the worthless Dietrich is causing them no end of trouble by his conduct. Let it be said on his behalf that his daughter, Mrs. Knipping, atoned in future years, to some extent at least, for her father's shortcomings. She was the faithful and trusted attendant of her aunt Caroline during the last years of her long life. As years roll on, the record remains equally mournful: "His strength is now (1815), and has for the last two or three years not been equal to the labour required for polishing 40-feet mirrors"; at a Royal "fête at Frogmore" (1817) "I was obliged to go home with my brother," who "found himself too feeble to remain in company." But feebleness and ill-health gave no remission from a showman's duty: "The Archduke Michael of Russia, with a numerous attendance, came to see Jupiter," etc. (1818). Princesses, archdukes, lords and ladies came to see many objects in the 10-ft. and other telescopes (1819), unaware that the sage-astronomer, whom they were treating as a showman, was hastening to the grave. His sister "with much concern saw that he had exerted himself too much above his strength."

"A small slip of yellow paper" traced by a tremulously feeble hand, indicating the appearance of "a great comet with a long tail," was among the last communications from Herschel to his sister. She kept it as a relic of a lamp of life that once burned brightly, and was then flickering in the socket. For three years it continued to flicker, till the end came, on August 25, 1822. A noble light of humanity and science then set for ever on this earthly scene.

The writings of Herschel may be said to be contained in that wonderful repository of science and observation, *The Transactions of the Royal Society*. He contributed sometimes one, sometimes two or three or four papers in a year between 1780 and 1818, except in the years 1813 and 1816. Few scientific writers were so active with their pen. Everard Home, in a different sphere of research, surpassed him in the number of his contributions; but two thousand quarto pages—to say nothing of valuable and instructive diagrams—filled with wonderful discoveries, rare or useful observations, noble theories, and lofty imaginings formed a life-work of unusual merit. They were written in a language that became familiar to him in a foreign country only after he passed his twentieth year. Titles and text are not unfrequently somewhat prolix, but what was a peculiarity of the age cannot be attributed as a fault to Herschel. His sister, to whom the world is indebted for the form in which not a few of these papers appeared, carefully preserved seventy-two of her brother's in five volumes, which she transferred to his son's keeping in 1830. Only sixty-nine papers were laid before the Royal Society and one before the Royal Astronomical. What the other contents of her bundle were she has not informed us.

In the writings of Herschel and his sister there is a singular silence on the affairs of another world than this material universe, in whose vast surroundings we spend our brief earthly life. However, it is not an unbroken silence. His sister repeatedly refers to a future state, and to a home she longed for, a meeting-place with those she loved and worked with on earth. She left England less than two months after her

brother William's death, "parted with her little property," and "thought at that time she should not live a twelvemonth." She lived for twenty-six years after, "alone" and disappointed. During that long period she gave expression to hopes which may be justly regarded as echoes of sentiments expressed by her brother. Unquestionably her mind was a mirror that truly reflected his. It is evident also from his conversation with Thomas Campbell that he entertained a horror of hypocrisy, which may have imposed silence on him when he would otherwise have spoken out. Once, in a philosophical paper, he did speak out on a future state of rewards and punishments. Had the matter not lain very near his heart, he would scarcely have written as he did. The subject of the paper was the Constitution of the Sun. Referring to the views of certain writers on the place of punishment for the wicked, he says—

"The sun, viewed in this light, appears to be nothing else than a very eminent, large, and lucid planet, evidently the first, or in strictness of speaking, the only primary one of our system; all others being truly secondary to it. Its similarity to the other globes of the solar system with regard to its solidity, its atmosphere, and its diversified surface; the rotation upon its axis, and the fall of heavy bodies, leads us on to suppose that it is most probably inhabited, like the rest of the planets, by beings whose organs are adapted to the peculiar circumstances of that vast globe.

"Whatever fanciful poets might say, in making the sun the abode of blessed spirits, or angry moralists devise, in pointing it out as a fit place for the punish-

ment of the wicked, it does not appear that they had any other foundation for their assertions than mere opinion and vague surmise; but now I think myself authorized, *upon astronomical principles*, to propose the sun as an inhabitable world, and am persuaded that the foregoing observations, with the conclusions I have drawn from them, are fully sufficient to answer every objection that may be made against it."

A man who filled the world with his renown as Herschel did, and who charmed all who happened to meet him as we know he charmed Miss Burney, Thomas Campbell, and Niemeyer, could not have been expected to leave this life without worthy commemoration from a poet's pen. Dr. Burney's Herscheliad was never published; Campbell preserved silence except in poetic prose, written while the astronomer was still living; and no one seems to have addressed himself to what was almost a duty of the age, except a writer, who hailed from Teversal Rectory, and was unable to force Uranus with its proper quantity into a line of poetry.[1]

> "Herschel, alas, great astronomic sage,
> Has sunk in death, yet full of honoured age,
> Through widest space the heavenly orbs he viewed,
> The comet's track, and stars unnumbered shewed;
> Ouranus first he saw, with all its train,
> And fires volcanic found in Luna's plain."

The Herscheliad could scarcely have contained poorer or more unworthy lines.

Far more worthy of record is the eulogium passed by Arago: "We may confidently assert, relative to the

[1] *Gentleman's Magazine*, vol. xcii. (1822).

little house and garden of Slough, that it is the spot of all the world where the greatest number of discoveries have been made. The name of that village will never perish: science will transmit it religiously to our latest posterity."

CHAPTER XII

DOUBLE STARS AND NEBULÆ

WITH the intuition of genius, Herschel, at an early period in his career, leaped to the conclusion that, as a planet revolves round the sun, so, in the regions of space, stars may revolve round stars, or sun round sun. It was a magnificent idea, apparently beyond proof, and would be reckoned among the useless things of science. "We have already shown," he wrote in 1803, "the possibility that two stars, whatever be their relative magnitudes, may revolve, either in circles or ellipses, round their common centre of gravity; and that, among the multitude of the stars of the heavens, there should be many sufficiently near each other to occasion this mutual revolution, must also appear highly probable." A sun of enormous size and brightness revolving round another sun as big or as bright, but it may be of a different colour, might be and really was regarded as the dream of a poet, imagining things that mathematics, with inexorable logic, gave no countenance to. But imagination sometimes realises truth long before the facts of science make it known. It was so here. "I shall therefore now proceed to give an account of a series of observations on double stars, comprehending a period of about twenty-five years, which, if I am not mistaken, will go to prove that many of

them are not merely double in appearance, but must be allowed to be real binary combinations of two stars, intimately held together by the bond of mutual attraction."

Herschel's first catalogue of double stars was presented to the Royal Society in a memoir of fifty pages on January 10, 1782. It was a work of enormous labour to be undertaken and carried out by a hard-working musician during the nights, that followed days of absorbing business. Of the number 269, contained in this catalogue, 227 had not been noted by any astronomer before him. It was not only a new field of research he may be considered to have opened up. He had also two distinct ends in view, which may be said to have been equally novel. One of them was, by means of these double or triple systems, to discover the distances of the stars from our sun, and the other to ascertain whether "small stars revolved round large ones." He failed in the former, he was successful in the latter. The arithmetic of the one was too hard for him; the poetry of the other was reduced to the commonplace of fact, after a waiting period of twenty-five years.

Everyone knows that if a tree and a house be in the same line of sight from a distant spectator, the eye of the spectator may imagine the tree to be at the same distance as the house, but cannot measure the space between them. We cannot see distance; it is an acquirement gained by experience from the sense of touch, and gained so insensibly that we think we see distance in front of us, height or depth, it may be, while, in fact, we only see length and breadth. An observer, seeing two stars so close that, to the naked eye, they seem only one, may consider

them both at the same distance. A little reflection, however, soon convinces him that the one star, though shining at a vast distance from the other, may be so placed in a line drawn from our eye to the latter as to be nearly or altogether eclipsed by it. Sometimes these stars are so close that the two pass for one, till an improvement in the telescope separates the companions, and shows them to be distinct. Herschel had this experience, and one of the most singular instances of it is not yet thirty years old. The dog-star Sirius is among the best known stars in our southern skies. Its brightness is forty- to sixty-fold that of the sun, its distance is such that a flash of light from it takes perhaps ten years to reach our eyes, and its weight exceeds that of two of our suns. This vast and brilliant sun was found to indulge in vagaries which were, and some of which still are, the puzzle of astronomers. They could not see, and therefore did not know. But although they could not see, they could imagine what the unseen cause of these vagaries was: for "the eyes of the mind can supply the want of the most powerful telescopes, and lead to astronomical discoveries of the highest importance."[1] Another star in the neighbourhood of Sirius, the mathematicians said, is moving round him. They calculated its orbit, they told observers where to apprehend the disturber, but in vain. At last the eighteen-inch object-glass, made for the Chicago Observatory in the United States, was turned on Sirius by way of trial. Great was the surprise of the manufacturers when they saw that the mighty sun had a fainter but a very bulky companion in his company, and was seen in the direction pre-

[1] Arago, *Biographies*, etc., p. 224.

dicted by mathematicians. It is twice as heavy as our sun, but does not give a fiftieth part of the light. Stars then may be double, or treble, or even quadruple by nature, or by the accident of position.

Comparing his own observations and such others as he could procure, Herschel calculated that the one star moved round the other, or that both moved round their common centre of gravity in the following double stars:—

Castor in about 342 years 2 months.
γ Leonis in about 1200 years.
ϵ Bootis in not less than 1681 years.
δ Serpentis in about 375 years.
γ Virginis in about 708 years.[1]

Another double star that he carefully examined was Zeta Herculis. It presented him with a sight "which is new in astronomy; it is, the occultation of one star by another." For twenty-one years he continued to keep a watch on the star. After twenty years had passed he could no longer perceive the smaller of the two companions. The following year he found "the apparent disk a little distorted; but there could not be more than about $\frac{3}{5}$ of the apparent diameter of the small star wanting to a complete occultation." But the observations made were not sufficient to determine the nature of the motion that produced these effects. The long period of 1681 years set down against ϵ Bootis, Herschel himself points out as subject to uncertainties, which it will take long to clear up.

[1] "One thing very remarkable I must tell you, γ Virginis is now *a single star* in both the twenty-foot, and the seven-foot equatorial ! ! !" (Sir John Herschel, March 8, 1836). He means that one of the two suns had eclipsed the other.

A slight mistake in exceedingly small measurements may cause serious errors in the calculated times of revolution.

It should not be forgotten that the King's equerry whom Miss Burney, in her gossip from Windsor Castle, calls Colonel Welbred, foretold that time would do justice to Herschel, and turn the laugh at him against the laughers. And time has done him justice with a most ungrudging hand. Eight years after his death, it was asked by a leader of modern enlightenment, "What length of time must the cosmologist suppose necessary to reduce a gaseous nebula into a permanent planetary system? Experience shows pretty clearly the inutility of such speculations." . . . Of the moon's "origin and internal structure we neither know, nor ever can know, anything whatever. And if such is the result of our researches respecting a body placed almost in our immediate vicinity, there is little reason to hope that we shall be more successful with regard to those whose distances are so great that the most powerful telescopes are required to render them even visible."[1] This was written in 1830; it was ill-natured disparagement of a noble attempt to solve the mysteries of the universe, and to give practical proof of man's kinship with God; it was wholly unscientific. In 1842 another greatly-extolled writer declared that in that region of inquiry there did not exist any discovered, or even, without doubt discoverable phenomenon.[2] The equerries of Windsor might be laughed at and forgiven; the scepticism that prompted men of science to bid their brethren fold their hands and do nothing, was an unpardonable sin against truth. It

[1] *Edin. Rev.* li. 101. [2] Comte, *Nineteenth Century* (1897), 908.

was of the same nature as the scientific proof that steamboats could not cross the Atlantic, and was belied, as the other was, by facts.

To Herschel then belongs the credit not merely of having suspected the revolution of sun round sun in the far distant realms of space, but also of actually detecting the fact that this was going on among the stars. He has the credit also of having, with imperfect appliances, measured the angles which enabled him to calculate the times of revolution of these systems of suns. It was a beginning, a wonderful beginning of a new departure in man's warfare with ignorance, and with the bonds that tie him down to the earth. He did not know, probably he was so wrapt up in his own conceptions of the usefulness of the telescope, that he could not imagine a more potent revealer of the secrets of the universe than a gigantic mirror at the bottom of a gigantic tube, or an immense eye at the object end of a telescope. A glass prism has done what the telescope could not do, revealed double stars where they were not known to exist, shown their rates of motion to or from us, and where an unseen ball is a companion to a living and a lighted sun, told us what they are made of, and enabled us to weigh them as if they were in the scales of a balance. To be able to do this, or apprehend the way it has been done, or even to know the fact, lifts human nature to a loftier height than it ever attained in the past, and the pioneer in this elevation of mankind was originally a bandsman in the Hanoverian Guards, a musician of Bath. Nor should it be forgotten that the improvement of the telescope, with which these revelations of the secret things of the starry heavens

are closely connected, was largely his work. He laboured indefatigably himself; he invited, he also aroused into honourable emulation, the rivalry of others to equal or surpass his achievements.

What Herschel could only suspect or assert, the glass prism has proved. These mighty suns, "in number numberless," are made of the same materials as our earth and our sun—iron, magnesium, hydrogen, sodium, etc. The vast universe is governed by the same laws, and made of the same matter. It is, so to speak, the work of one and the same building hand. To have risen to this simple truth by exploring the suns and systems of the universe is a reward worth all the time and trouble spent in working it out. Mankind, in this respect alone, stands on a loftier platform now than half a century ago. Oneness of plan, manifested in this widespread oneness of working, implies oneness of the worker. A lofty moral truth has resulted from the labours and speculations of which leaders of scientific truth in Europe formerly saw only the inutility. The Maker, Governor, and Upholder of all these worlds and universes is one and the same. Who He is, what is His central seat of power no telescope, no glass prism can reveal. Amid the wonders of infinite space and time, our standards of measurement and knowledge may be said to be our five senses, and if one of these, sight, were taken from us, our sphere of knowledge would be immeasurably reduced in extent. On the other hand, an addition to the senses we have, a quickening of the inner light, might reveal this Builder of worlds, His palace, His living armies, with a distinctness, a fulness hitherto unknown. Herschel evidently thought

this when he stood in wondering awe before the hole in the heavens.

That Herschel fell into mistakes regarding double stars cannot and need not be denied. It was unavoidable that the first traveller in an unexplored region, billions of miles distant from our earth, should err in tracing paths, measuring time, and estimating distances. He failed in his calculations with γ Virginis, which he represented as two companions that revolved round a common centre in 708 years. His son by a careful discussion of the observations made since 1718 showed that the time of revolution was not 708 years but 513. It was also predicted that the smaller of the two companions would reach the point where it is nearest the larger in the beginning of 1834. Even these revised calculations proved to be incorrect, for it did not reach that point till two years later. Observations of the star were then renewed for several years; new calculations were made, and the time of revolution of the lesser companion round the greater was found to be 182 years. But it came out that the orbit of 1834, with the time 513 years, was nearly the same, in part of its course, as the true orbit, and was "a curious example, and by no means the first in the history of the progress of discovery, where of two possible courses, each at the moment equally plausible, the wrong has been chosen."[1]

But Herschel's study of the fixed stars and of the unity of plan in nature went farther than we have yet traced. A paper read by him in 1814 contains the following facts, that might almost have been prophecies of wonders in store for men—"Stars although

[1] *Edin. Rev.*, 1848, 132–33.

surrounded by a luminous atmosphere, may be looked upon as so many opaque, habitable, planetary globes; differing, from what we know of our own planets, only in their size, and by their intrinsically luminous appearance. They also, like the planets, shine with differently coloured light. That of Arcturus and Aldebaran, for instance, is as different from the light of Sirius and Capella, as that of Mars and Saturn is from the light of Venus and Jupiter. A still greater variety of coloured star-light has already been shewn to exist in many double stars, such as γ Andromedæ, β Cygni, and many more. In my sweeps are also recorded the places of 9 deep garnet, 5 bright garnet, and 10 red coloured stars, of various small magnitudes from the 7th to the 12th.

"By some experiments on the light of a few of the stars of the 1st magnitude, made in 1798, by a prism applied to the eye-glasses of my reflectors, adjustable to any angle, and to any direction, I had the following analyses:

"The light of Sirius consists of red, orange, yellow, green, blue, purple, and violet.

"α Orionis contains the same colours, but the red is more intense, and the orange and yellow are less copious in proportion than they are in Sirius.

"Procyon contains all the colours, but proportionally more blue and purple than Sirius.

"Arcturus contains more red and orange and less yellow in proportion than Sirius.

"Aldebaran contains much orange, and very little yellow.

"α Lyræ contains much yellow, green, blue, and purple."

The foundation of what may be called a new science was thus laid by Herschel more than half a century before anything was built on it.

In that paper also he embodied curious speculations on *the growth of stars*: "If the nebulosity should subside into the star, as seems to be indicated by the assumed form of the fan-shaped nebulæ, the star would receive an increase of matter proportional to the magnitude and density of the nebulosity in contact with it."

Another of the subjects specially studied by Herschel from an early period in his career was the white clouds or nebulæ seen, even with the naked eye, in various places among the stars. The telescopes of astronomers had not done much to add to their number or reveal their peculiar forms till he took the matter in hand. In 1786 he laid before the Royal Society a "catalogue of a thousand nebulæ and clusters of stars." Three years after, he presented the Society with a "catalogue of a second thousand new nebulæ and clusters of stars"; and in 1802 he added "a catalogue of 500 new nebulæ and clusters of stars." A field of discovery so rich he had been left to reap alone, except in the assistance, the invaluable assistance, which he received from his devoted sister Caroline. He looked upon star-clusters and nebulæ as building stones used by the Creator in constructing the universe; to catalogue, to watch, and to measure these building stones was a long step taken in ascertaining the plan on which the Almighty Architect proceeded. Herschel was laughed at, most unfairly laughed at, as a "lively and amusing" dreamer; science has proved that he was a noble pioneer of modern discoveries, which inspire mankind with awe.

The work of observing, measuring, and recording these worlds of wonder, and sometimes of surpassing beauty even when seen in the magic mirror of a reflector, was enormous: but this indefatigable worker, with his like-minded sister-helper, seemed never to weary in his marvellous efforts to lift the curtain that hid Creation's glories from man. What these glories seemed (to him) to mean was unfolded in 1811 in a memoir, which anticipated by many years the doctrine of evolution taught by Darwin, and which showed the progress, slow it might be, "for, in this case, millions of years are perhaps but moments," but sure, of a vast body of gas condensing into a sun or suns with a train of planets around.[1]

When Herschel entered upon this inquiry he believed that these nebulæ, or whitish clouds or milky ways are clusters of stars, too far off to be resolved into separate points of light, but blended so together as to assume the appearance of a little cloud in the depths of space. "Longer experience and a better acquaintance" with them induced him to change his mind. Vast masses of gas, in which a few stars were sometimes seen, or through which they shone from a greater distance, were believed by him to exist in space, besides those which an increase of telescopic power could *resolve*, as the phrase was, into stars.[2] It was the idea of a far-seeing mind, feeling its way to truth, and, in our

[1] "The reason for not having a more circumstantial account of such a number of objects, is that they crowded upon me at the time of sweeping in such quick succession that of sixty-one I could but just secure the place in the heavens, and of the remaining three hundred and sixty-three, I had only time to add the relative size" (*Phil. Trans.* for 1811, p. 290).

[2] *Phil. Trans.* for 1811, p. 270.

own day, it has been proved true. The prism has shown that these inconceivably vast masses of gas exist. Justice to Herschel requires that his rights to the first announcement of this new and startling view of the gradual formation of worlds should not be overlooked, as is sometimes done.[1] "The profound awe," says the discoverer of the gaseous nature of some nebulæ, "which I felt on looking for the first time at that which no eye of man had seen, and which even the scientific imagination could not foreshow," is the well expressed wonder of true science, when it penetrates into the workshops of the Almighty, but Herschel's imagination had done more in 1811 than "foreshow" the discovery made fully by Sir William Huggins in 1864. The imagination of William Herschel penetrated into this secret house of wonders, and gave expression to what was believed to be going on in eternal ages and through infinite space.

There are two magnificent nebulæ to which astronomers have specially turned their telescopes, the one in Orion and the other in Andromeda. Writing in 1811, after thirty-seven years' study of these wonderfully mysterious clouds, Herschel thus speaks of "the great nebula in the constellation of Orion discovered by Huyghens. This highly interesting object engaged

[1] "Sir William Herschel supposed that they [nebulæ] were all really star-clusters, but so enormously remote that even the most powerful telescopes could not render visible the stars composing them" (Wallace, *The Wonderful Century*, p. 44). This is a singular statement to come from the gifted author or co-author of the Darwinian theory. The reduction of the immensely vast to the comparatively small was Herschel's view of development or evolution in the realms of space; the growth of organic life from the simple cell to the living forms of earth —the inverse process—is the idea or hypothesis of natural science to-day. See *Phil. Trans.*, 1791, pp. 73–83.

my attention already in the beginning of the year 1774, when viewing it with a Newtonian reflector I made a drawing of it, to which I shall have occasion hereafter to refer: and having from time to time reviewed it with my large instruments, it may easily be supposed that it was the very first object to which, in February 1787, I directed my 40-feet telescope. The superior light of this instrument shewed it of such a magnitude and brilliancy that, judging from these circumstances, we can hardly have a doubt of its being the nearest of all the nebulæ in the heavens, and as such will afford us many valuable informations. I shall however now only notice that I have placed it in the present order because it connects in one object the brightest and faintest of all nebulosities, and thereby enables us to draw several conclusions from its various appearance."[1] By nebulosity or nebulous matter he meant "that substance or rather those substances which give out light, whatsoever may be their nature, or of whatever different powers they may be possessed."[1] From a laborious examination of these vast regions of visible nebulous matter, Herschel found reason to conclude that the power of gravitation was condensing the matter towards one or more centres, which shone with greater brilliance than the rest of the mass. A motion of rotation round an axis would also probably result from innumerable particles pressing towards a centre, and the matter which did not condense into a nucleus—perhaps a star or sun—

[1] *Phil. Trans.* for 1811, pp. 278, 279, 277, 313. "The nature of diffused nebulosity is such that we often see it joined to real nebulæ." He means apparently gas sometimes very rare joined to matter condensed or condensing into stars.

would "remain expanded about the nucleus in the shape of a very extended atmosphere; or it may be of an elastic nature, and be kept from uniting with the nucleus, as their elasticity causes the atmospheres of the planets to be expanded about them. In this case we have another property of the nebulous substance to add to the former qualities of its matter."

No one can read even an outline of these interesting speculations by an adventurer into the workshops of creation, without feeling awed by the boldness and sublimity of his views, as well as desirous of knowing what else he saw in his magic mirror, or thought he saw, of the machinery in motion. What he has told us of a mighty volume of nebulous matter is that "a nucleus, to which these nebulæ seem to approach, is an indication of consolidation," and that the faintness of the light in the parts outside the nucleus arises from "a gradual diminution of the length and density of the nebulous matter, occasioned by its gravitation towards the nucleus into which it probably subsides."[1] He believes that "a pretty bright round nebula about a quarter or one minute in diameter, and looking no bigger than a pea, may have shrunk into itself till it is now nineteen hundred times more dense than at first, —a proportion of density more than double that of water to air."[1] In another case he calculates that "the condensation may have reduced the nebulous matter to less than the one hundred and twenty-two thousandth part of its former bulk."[1] To understand what these figures mean, suppose a sphere whose radius is nearly three thousand millions of miles, or as far as from the sun to our outermost known planet,

[1] *Phil. Trans.*, 1811, pp. 308, 310, 311, 315, 316, 318.

Neptune, to be filled with gas, luminous or not. It would not occupy more than a fortieth part of the space in the heavens occupied by the great nebula in Orion, and it is doubtful if our best telescopes reveal the whole of that nebula's extent in any direction. It is within such vast spaces that Herschel imagined this world-making process to be going on. Man's imagination quails in his attempt to grasp the space required for such a workshop, the tools employed, or the time taken to condense "nebulous matter" into dazzling suns or dark companions.

We are so much accustomed to feast our eyes on drawings of a few magnificent and singularly shaped nebulæ, that thought is apt to overlook the vast numbers of them scattered over the heavens in all stages of size or progress. Herschel did not fall into this mistake. His object was higher than to satisfy curiosity or to excite wonder. He had the feeling that there was a process going on, of which he believed he could trace not a few of the stages. The smallest and the least wonderful of the nebulæ might thus prove to be as important in tracing out this progress, as the most awe-inspiring. Nor did he look upon all of them as resolvable into stars or masses of shining matter, more or less rare. He believed that some of them were not luminous, but dark; but he made no attempt to explain, as may be at least attempted to-day, how a vast mass of invisible gas may become lighted up, and send its brightness off on a journey of ten or twenty or fifty years, to publish to us the changes that, in process of ages, had taken place in its nature. It was the discovery of world-making he was aiming at in these long and laborious, but not wearisome researches. Others

have followed in his footsteps with a better equipment of instruments, if not with a richer endowment of insight or genius. Others still have looked upon his lifelong quest as an attempt to reach the foot of the rainbow ladder, or to master the secret of the philosopher's stone. His papers remain a wonderful monument of ingenious research and marvellous discovery, of lofty imaginings and reasoned conclusions.

These nebulæ and clusters of stars Herschel called milky ways, different from the great Milky Way, in which our solar system is imbedded. He held at first that they are in no respect connected with our milky way, but are star-islands or world-systems, perhaps only in process of formation, at immense distances from our sun, outlying provinces of creation, as it were, in the vast ocean of ether, or constructions only begun in the realms of space. He is supposed to have fallen from this opinion in his later years, and to have imagined that all these milky ways and star-clusters were connected with ours. His latest papers give no indication of this change of view. He appears indeed only to have changed his view in so far as to have regarded our milky way as the greatest of all the milky ways, visible in our telescopes: but on this point he was scarcely justified in speaking, as the distance of the nearest nebula not only was and continues to be unknown, but the means of determining the distances of these white clouds have not yet been discovered. It is thought that the great nebula in Orion, if not the nearest to us, is among the nearest. Herschel maintained this. He had some grounds also for believing that changes had taken place in the positions of the nebulous matter during the thirty-seven years he

had been watching, and still greater changes since Huyghens, a century and a half earlier, gave a picture of it in his *Systema Saturnium.* "The various appearances of this nebula," Herschel writes, "are so instructive that I shall apply them to the subject of the partial opacity of the nebulous matter. . . . For when I formerly saw three fictitious nebulous stars, it will not be contended that there were three small shining nebulosities, just in the three lines, in which I saw them, of which two are now gone, and only one remaining. As well might we ascribe the light surrounding a star, which is seen through a mist, to a quality of shining belonging to that particular part of the mist, which by chance happened to be situated where the star is seen. If then the former nebulosity of the two stars which have ceased to be nebulous can only be ascribed to an effect of the transit or penetration through nebulous matter which deflected and scattered it, we have now a direct proof that this matter can exist in a state of opacity, and may possibly be diffused in many parts of the heavens without our being able to perceive it."

It would be unjust to Herschel to pass over the condemnation of his views, pronounced by Sir David Brewster in his *Life of Sir Isaac Newton.* Without mentioning the name of William Herschel, or of La Place, who advocated the same views, Sir David writes as one who felt sure that Newton, for mathematical reasons alone, would have taken a side against this Nebular Hypothesis.[1] In the last of the famous four letters written by Sir Isaac to Dr. Bentley, the great classical scholar and the author of *Phalaris,* he enters

[1] *Life of Newton,* ii. 130.

into a mathematical criticism of the opinion of Plato "that the motion of the planets is such as if they had all been created by God in some region very remote from our system, and let fall from thence towards the sun, their falling motion being turned aside into a transverse one whenever they arrived at their several orbits." This, of course, is wholly unlike Herschel's theory, or that of Laplace. But of these letters Sir David says: "In the present day they possess a peculiar interest. They show that the *Nebular Hypothesis*, the dull and dangerous heresy of the age, is incompatible with the established laws of the material universe, and that an omnipotent arm was required to give the planets their position and motions in space, and a presiding intelligence to assign to them the different functions they had to perform."

These views of Sir David Brewster, eminent man of science though he was and sincere believer in an almighty arm ruling all the motions of material bodies, do not seem justified by facts. Even his great name is not weighty enough to counterbalance that of Laplace, when the former affirms and the latter denies that the *Nebular Hypothesis* "is incompatible with the established laws of the material universe." Newton's speculations on Plato's dream of the origin of planets had nothing to do with the hypothesis in question. It may be "a dull and dangerous heresy," as Sir David believed, "but it denies neither an almighty arm nor a presiding mind." Recent discoveries have given more probability to the theory—if we are entitled to use that name: and Herschel's inductions from observed and classified facts have gone far to prove that Laplace's

imaginings rest on a more solid foundation than theories, at their birth, can usually boast of.

In pursuit of his favourite study—the plan of the Creator in constructing the Temple of the Heavens—Herschel, with fuller knowledge, and after many years of labour, departed from Cassini's simple classification of nebulæ, and adopted another in closer agreement with facts. It was as follows:—

Class I.	Bright nebulæ	288 in all.
„ II.	Faint nebulæ	909 „ „
„ III.	Very faint nebulæ . . .	984 „ „
„ IV.	Planetary nebulæ or stars with burs, with milky chevelure, with short rays, remarkable shapes, etc.	79 „ „
„ V.	Very large nebulæ . . .	52 „ „
„ VI.	Very compressed and rich clusters of stars	42 „ „
„ VII.	Pretty much compressed clusters	67 „ „
„ VIII.	Coarsely scattered clusters of stars	88 „ „

As he entered these nebulæ on a star map, it was evident to the eye that the parts of the heavens at a distance from the Milky Way are most abundant in white clouds. Of a connection between them and the Milky Way he does not appear to have been certain. We must leave it as he left it—in uncertainty and doubt. Future ages may determine whether the whole material universe, designed by one mind, governed by the same laws, built of the same materials, and upheld for purposes in which the mighty littleness of man seems to play a not unimportant part, moral as well as intellectual, has been spread out before our eyes. We can only look on in wondering adoration at the

glory and vastness of a temple, built by Almighty Power and Wisdom, the forth-puttings of whose hand we can see and trace, but whose palace and presence are hidden in brightness impenetrable to our sight.

Astronomy has made vast strides in knowledge of the stars since Herschel's death. Other magicians, imbued with his spirit, and wielding a more wonderful rod of power than his 40-feet reflector, have arisen to walk in his footsteps, and to tread the paths of discovery, which more or less dimly he saw and walked in—double stars; treble systems; eclipses of suns; youthful stars; dark or dying worlds; star charts; photographic plates, and vast volumes of gas, lighted or dark. More even than in his days have the barren heavens proved to be a land of wonders to curious man.

CHAPTER XIII

THE SURVIVOR

Of those who helped Herschel onward to fame, all were dead but his sister Caroline. Dr. Watson, and Sir Joseph Banks, the King and Herschel himself were gone. A pleasant and useful fellowship of great minds, great in respect of rank or great in intellect and heart, had come to its close. It had lasted for about forty years, more or less; and the continuance of it so long without break or jar reflects the highest credit on all four. A union of hearts and minds so unusual is worthy of a passing notice.

Sir William Watson did not belong to the Triumvirate as it was called, but of him Herschel always spoke with the deepest respect. Unworthy and unscrupulous men, when they think themselves able to climb without further help, have no repugnance to kick away the ladder by which they first mounted into fame. Herschel did not belong to that contemptible class. His was a noble nature, and as generous as it was noble. Watson offered to assist him with money, but he preferred to meet the cost of experiment or manufacture out of his own labours. It was a noble resolve. But almost from the first he confesses obligation, and finds a certificate for himself by linking his name with Watson's. The man with whose fame

Europe was ringing, honoured himself by this modesty of bearing and true manhood. "Grieved to see the sad change in Sir William's health and spirits," Caroline Herschel wrote of their early friend when she met him and his wife at her brother's house on May 10, 1817, "I felt my only friend and adviser was lost to me."

The Triumvirate was composed of the King, Sir Joseph Banks, and Sir William Herschel.

The King was dead. Whatever may be said or thought of him in other respects, it should always be borne in mind that, after the difficulties incident to Herschel's introduction at Court had been overcome, he proved himself a munificent patron of science and an enlightened friend of the great observer. Accustomed himself to live in the centre of a crowd in his palace, on the terrace at Windsor, and in his public appearances, it would not occur to him that similar publicity could be otherwise than agreeable to his astronomer. When he bargained for Herschel's time being devoted, among other things, to receiving visits from Royal or titled nonentities, and showing them his instruments, he did not consider that it was a drain on the astronomer's time and strength, which ought not to have been asked from him. Caroline Herschel, who saw the mischief wrought by this waste of energy, the irritation caused, and the danger run from standing for hours on wet grass to play the showman to a crowd of thoughtless nobodies, complains bitterly, and not without reason, of the arrangements thus made. But the King cannot fairly be held blameworthy. Miss Burney suffered in nearly the same way. Her attendance on Queen Charlotte was a burden on body and soul,

similar to the claims made on Herschel by visitors from Windsor Castle. Macaulay reprobates, and justly reprobates, the thoughtless cruelty, to which it exposed a woman who could have earned by her pen ten times the income she received from dancing attendance on a queen. But the Queen was not altogether in fault in her case; nor was the King in Herschel's. It was Court etiquette, cruel and thoughtless unquestionably; —"a slavery of five years, of five years taken from the best part of her life, and wasted in menial drudgery or in recreations duller than even menial drudgery, under galling restraints, and amidst unfriendly or uninteresting companions."[1] It was a huge mistake to cramp the genius of the novelist or the astronomer by the formalities and triflings of a Court. It did little or no harm to the latter; it did irreparable wrong to the former. People who have lived in a crowd all their lives, to whom indeed it is the breath of life, cannot understand that it may be poison to genius.

Sir Joseph Banks also was dead. A year after his death a German visitor to this country gives a pleasing picture of an uncommon triumvirate of rank and science. "In England," he says, "people have long been accustomed to associate with their recollections of their late revered Monarch, the names of these two veterans in science, Herschel and Banks, both not only of nearly the same age with the King, but also distinguished by him with peculiar favour, and frequent personal intercourse. All the three members of this singular triumvirate were still living when I visited England; now the astronomer is the only survivor." "With good reason did Cuvier, in the panegyric he pro-

[1] Macaulay, vii. 25.

nounced on Sir Joseph before the French Academy, assert that *whenever a worthy disciple, or man of letters, fell in his way, he opened to them his treasures of nature with the greatest liberality.*" Herschel experienced from him the full benefit of this generous, ungrudging nature.

Following the example of his predecessor in office as President of the Royal Society, Sir Joseph, possessed of an ample fortune which enabled him to indulge the generosity of his heart, gave receptions to learned men and travellers on Sunday evenings. The stranger thus describes what he then saw. "I found the veteran in the middle library, in full dress, with the broad ribbon of the order of the *Bath* over his shoulder and breast;[1] just as he used to appear when presiding at the meetings of the Royal Society. Being infirm in the feet, Sir Joseph sat in an arm-chair on rollers, his left arm resting on a table near him.[2] He was, it is true, scarcely more than the outward shell of a mind formerly so animated; both his apprehension and recollection being weak; but his features bore a most engaging expression. Every stranger was at least announced to him, and if he had anything to shew or communicate, he immediately laid it before him."

This generous, noble-hearted man did much to soften the horrors of war in the long and bloody strife between this country and France. "During the voyage of La Perouse, the French circumnavigator, he induced

[1] As he is represented in the portrait of him painted by Phillips, in the possession of the Royal Society.

[2] For fourteen or fifteen years previous to his death, he lost the use of his lower limbs so completely from gout as to oblige him to be carried or wheeled by his servants in a chair: in this way he was conveyed to the more dignified chair of the Royal Society.

the British Government to allow him to sail in all seas unmolested. He himself endeavoured, by means of his extensive correspondence, to procure some certain accounts as to the disastrous result. When a considerable collection of natural curiosities, which Labillardière had sent to France during his voyage, fell into the hands of English privateers, and became the property of the English Government, Sir Joseph generously exerted his influence again, and the result was that the cases were immediately sent to France, without having even been opened."[1]

A king, a landed gentleman of great wealth, and a musician from Bath formed the triumvirate in science,[2] of which our countrymen used to speak, and were deservedly proud for twenty years before and for twenty after the beginning of the present century. All three were dead, but they were survived for a quarter of a century or more by a lady, who made herself famous in science and wore her well-won honours with the modesty of true deserving—Caroline Lucretia Herschel, the devoted sister and unwearied assistant of her brother William. With touching pathos she writes to Francis Baily in 1835, "It encourages me now to address you as an old friend, and I might almost say my only one, for death has not spared me one of those valuable men of the last century in whose society I had an opportunity of spending many happy hours, when they came to pass an astronomical night at Bath, Datchet, Clay Hall, and Slough." She re-

[1] This international courtesy was thus shown on no fewer than eleven occasions, and some of the collections are "now of inestimable value" (1896): Hooker, *Journal*, etc., p. xxxiii.

[2] Niemeyer, *Scots Magazine*, i. (1823), pp. 692-93.

mained, to the end of her long life, the same loving worshipper of departed greatness that she had been during her brother's lifetime, and the same outspoken critic of men and women whom she happened to meet. Thirteen years after she left England, she wrote: "Within the last two months I have been obliged to exert myself once more to answer two letters, one to Mr. De Morgan, the Secretary of the Royal Astronomical Society, the other to Mr. Baily (who, I suppose, is President), for they have been pleased to choose me, along with Mrs. Somerville, to be a member (God knows what for) of their Society." Promotion! she says, they call it in Hanover, and laughingly talks of "our Society, of which I am now a fellow!" She was then eighty-five years of age. Apparently she was of the same mind as Hannah More, who, when she found her name proposed as an honorary member of the Royal Society of Literature, wrote a strong remonstrance, declining the distinction, chiefly "because I consider the circumstance of sex alone a disqualification."[1]

In November 1838 she was also elected an honorary member of the Royal Irish Academy, Dublin: and besides she received in 1846, from the King of Prussia, a gold medal for science. Well earned though both of these honours were, she wrote with the modesty of true science, when she heard of the former, "I cannot help crying out aloud to myself, every now and then, '*What is* THAT *for?*' . . . I think almost it is mocking me to look upon me as a Member of an Academy: I that have lived these eighteen years (against my will and intention) without finding as much as a single

[1] *Life*, ii. 307, December 23, 1820. She was then seventy-five.

comet." At the same time she could flare up with true feminine fire when it seemed to her that her dignity, as a woman of science, was in any degree infringed. "This puts me in mind of Olbers saying somewhere," she wrote, "I had discovered five comets. Who wanted him to give the number of *my* comets when he knew them no better? As far as I recollect, Dr. Maskelyne has observed them all, and his observations on them are, I daresay, all printed in the volumes of the Greenwich observations—at least of some he has shown me the proof sheets. I never called a comet mine till several post days were passed without any account of them coming to hand." She was then ninety-two years of age, and Olbers had died more than two years before.

Caroline Herschel maintained to the close of her days the same habits of thrift, the same dread of not getting the two ends to meet, and the same foresight in providing means for ends that characterised her early life. She enjoyed a pension of £50 a year from the Civil List—a small allowance for so deserving a recipient. She had also an annuity of £100 settled on her by her brother's will—a small return, we should say, for the invaluable services she rendered, but a sum which she probably regarded as unnecessarily taken out of her "dear nephew's" pocket. "Let the time come when it may please God," she writes in her eighty-fifth year, "I leave cash enough behind to clear me from *all* and *any* obligations to all who *here* do know me. Even the expenses of a respectable funeral lie ready to enable my friend Mrs. Beckedorff, and one of my nieces to fulfil my directions.

"I hope you will pardon my troubling you with such doleful subjects, but I wish to show you that

my income is by one third more than I have the power to spend, for by a twelve years' trial I find that I cannot get rid of more than 600 thl. = £100 per year, without making myself ridiculous."

Her thoughts were not set on money, or on the respect which money, honourably earned, usually brings. The memory of the "best and dearest of brothers" clung to her with an all-absorbing power. It was her first and her last love. "You have made me completely happy for some time," she wrote from Hanover to his son, "with the account you sent me of the double stars; but it vexes me more and more that in this abominable city there is no one who is capable of partaking in the joy I feel on this revival of your father's name. His observations on double stars were from first to last the most interesting subject; he never lost sight of it in his papers on the construction of the heavens, etc. And I cannot help lamenting that he could not take to his grave with him the satisfaction I feel at present in seeing his *son* doing him so ample justice by endeavouring to perfect what he could only begin." When Sir John Herschel delivered the address that preceded the handing over to Bessel of the Astronomical Society's Gold Medal for determining, by means of the heliometer, the distance from us of the double star 61 Cygni, she was heart and soul with him when he said, "Gentlemen, I congratulate you and myself that we have lived to see the great and hitherto impassable barrier to our excursions into the sidereal universe—that barrier against which we have chafed so long and so vainly—almost simultaneously overleaped at three different points."[1] He

[1] *Astron. Soc. Trans.* xii. 448–53.

described this discovery of the distance of a fixed star as the greatest and most glorious triumph which practical astronomy has perhaps ever witnessed, and the three who shared the triumph between them were Bessel with 61 Cygni, Henderson [1] of Edinburgh with α Centauri, and Struve of Dorpat with α Lyræ. Bessel's object-glass, that he got cut in two to form a heliometer, Sir John saw at Munich before it was mounted, considered it invaluable, and believed that genius alone could have dared to divide it in two for the purposes of science. Caroline Herschel's delight, in her retirement, at the success of these three astronomers in following her baffled brother's lead may be imagined. To know that the parallax of a fixed star had been found by Bessel to be the $\frac{31}{100}$ of a second! To know that it was a double star! To know, besides, that the smaller of the two companion stars revolved round the larger in an orbit fifty times the diameter of the earth's orbit round the sun, or two and a half times that of Uranus! and to know also that the pair of stars were 670,000 times as distant from us as is the sun! To her these discoveries were a delightful commentary on her brother's words—"In this case, millions of years are perhaps but moments." The "little old woman" in the "abominable city" of Hanover, unable to endure "happy England," where her dead hero was buried, and where his son, her nephew, was a foremost name in the world of science, revelled in the news that

[1] It is only just to Henderson to say that he was preferred by Lord Advocate Jeffrey to the Edinburgh Professorship of Astronomy over his rival, Thomas Carlyle. Froude was guilty of an unpardonable blunder in printing the unwise and acrimonious criticism of Carlyle on Henderson's fitness for the post. Facts had given a verdict in Henderson's favour.

were brought her of hopes at last fulfilled, and thought longingly of the seven-feet reflector, with which she used to sweep the heavens, as it stood in the room beside her, but which she should never use again.

"How I envy you having seen Bessel," she wrote to her nephew in 1842—"the man who found *us* the parallax of 61 Cygni."[1]

"The seven-foot shall stand in my room, and be my monument," she wrote to her nephew in 1823; what to do with it was a puzzle to her. Her sweeper she thought of leaving to her girlhood's friend's daughter, Miss Beckedorff, but in 1840 it was consigned to "the hands of the good, honest creature, Dr. Hausmann." "The five-foot Newtonian reflector," she wrote that same year,[2] "is in the hands of the Royal Astronomical Society, and will be preserved by it as the little telescope of Newton is by the Royal Society, long after I and all the little ones are dead and gone." It was a source of justifiable pride to her as she neared the end.

Faithful to the memory and greatness of her departed brother, she resented every attempt at an imperfect or unworthy presentation of his life and works. What she should have done herself, and she had better means than others of doing it truthfully and faithfully, she left to the ignorant or the conceited to attempt. She could only rail at their efforts, and wish they had left the work alone. It was not just to them or to him. The world wishes to know something of those whose greatness of mind or achievement has enriched humanity or extended its knowledge of

[1] *Memoirs*, p. 327.

[2] "Five-foot Newtonian sweeper," *Memoirs*, p. 91.

nature. Herschel had done so in a pre-eminent degree. With good reason, then, the world said, Tell us about him; his faults, if he had any, we can forgive and forget; his virtues we can admire or follow. Caroline Herschel did not take this view of her duty. She left it to others to write what she could have written better, and to record what she knew at first hand, and they did not know at all or only as dull echoes of a resounding past. "The Germans are very busy about the fame of your dear father," she writes; "there does not pass a month but something appears in print, and Dr. Groskopf saw it stated that Professor Pfaff had translated *all* your dear father's papers from the *Phil. Trans.* into German, and which will be published in Dresden. I wish he had left it for some good astronomer to do the same." Evidently the acid of her temper had been called into action by Professor Pfaff. Her nephew describes him in reply as "a respectable mathematician, and I hope it is he who undertakes the work." "Johann Wilhelm Pfaff," she answers, "professor, in Erlangen, is the same who intends to translate your father's papers, but those only which he can get a copy of. The *Philosophical Transactions*, I am told, are not within his reach." The acid is a little sweetened; not much, and it is clear that Caroline Herschel at eighty-five does not differ in temper at least from the same lady at twenty-two. Alas! her inventory of books, pictures, etc., showed what she thought of the Professor's two-volume edition of her brother's collected works, "Abominable stuff! What is to be done with them? They are so prettily bound, I cannot take it in my heart to burn them." But she could lash with her tongue everybody who

even praised her dead hero. "Now we talk of biographies," she wrote twelve years afterwards, "I have no less than nine of my poor brother, and heard of two more, one by Zach, which I shall try to get sight of. There is but one or two which are bordering on truth, the rest being stuff, not worth while to fret about. The best is accompanied with a miniature of Reberg's *bad* copy." "Bordering on truth! stuff!" Her description of her own racy letters is equally amusing: "I was in hopes you would have thrown away such incoherent stuff . . . and not to let it rise in judgment against my, perhaps, bad grammar, bad spelling, etc."

Even a small matter became great where his name was concerned. "The following hint is only to you as a dear sister," she writes to her brother's widow, "for as such I now know you:—All I am possessed of is looked upon as their own, when I am gone; the disposal of my brother's picture is even denied me—it hangs in Mrs. H.'s drawing-room, where a set of old women play cards under it on her club day." Summary also was her judgment of anyone who attempted to rival or surpass her brother: "The fellow is a fool." Great was her excitement on learning that her nephew was preparing to complete in the southern hemisphere the gauging of the heavens, which his father had begun, and for many a year carried on in the northern. That was allowable. It was a war trumpet blown within hearing of a war horse, that had served its last campaign. "Dr. Tias, who travelled through Hanover, called on me to-day," she writes to Lady Herschel. "He talked strangely about my nephew's intention of going to the Cape of Good Hope. Mr. Hausmann told

me some weeks ago that the *Times* contained the same report, to which I replied, 'It is a lie!' but what I heard from Dr. Tias to-day makes me almost believe it possible. Ja! if I was thirty or forty years younger, and could go too? In Gottes nahmen! But I will not think about it till you yourself tell me more of it, for I have enough to think of my cramps, blindness, sleepless nights, etc." She was a wonderful "little old woman." Pointed at on the street, honoured by the Palace, and saluted with profoundest respect at theatre or concert, she wrote, "Next to listening to the conversation of learned men, I like to hear about them, but I find myself, unfortunately, among beings who like nothing but smoking, big talk on politics, wars and such like things." Her indignation flamed up as fiercely when she was ninety years of age as it used to do when she was twenty, especially at anyone who took her for what she was not, weak of will or understanding. "Thank God, I have yet sense enough left to caution you against being imposed upon by a stupid being, who would make you believe I died under obligations to any of the family. I know he has already, without asking my leave, passed himself off for my guardian, and is vexed at my being able to do without him. But I could not live without that little business of keeping my accounts; and by my last book of expenses and receipts may be seen, that I owe nothing to any body, but to my dear nephew many many thanks for fulfilling his father's wishes, by paying for so many years the *ample* annuity he left me." What a brave little old woman she was! Nobody but herself was at liberty to call her "an old poor sick creature in her dotage."

Sometimes at the theatre to be seen and saluted by all, sometimes at the palace to be honoured by the King's brother as his countrywoman, sometimes in correspondence with scientific men, and hearing of their achievements, she maintained to the last her cheerful interest in life. Though her eyesight was failing, and she could "hardly find the line again she had just been tracing by feeling on paper," her nephew writes of her in 1832, "She runs about the town with me, and skips up her two pair of stairs as light and fresh at least as *some folks* I could name, who are not a fourth part of her age. . . . In the morning till eleven or twelve she is dull and weary, but as the day advances she gains life, and is quite 'fresh and funny' at ten or eleven p.m., and sings old rhymes, nay, even dances! to the great delight of all who see her." It is such a picture of four score as Cicero would have been overjoyed to prefix as a frontispiece to his treatise on "Old Age," had it been available in his day. She spoke in her usual spirit of drollery of "her brittle constitution," and looked for it going to pieces in the great heats of summer fourteen years before it did. "My complaint is incurable," she says, "for it is a *decay* of nature. . . . What a shocking idea it is to be decaying! *decaying!* But, never mind—if I am decaying here, there will be as Mrs. Maskelyne once was comforting me (on observing my growing lean) the less corruption in my grave!" But, in view of the end, it is always to "the best and dearest of brothers," to her "dear nephew," and to her namesake, his little daughter, that her thoughts revert. She enjoyed the present; she revelled and lived in the past. "I have now received in all five letters," she writes to Lady

Herschel at the Cape of Good Hope. "Each time after having read them over again they are put by, under thanksgiving to the Almighty, with a prayer for future protection."

"Writing to my absent friends is one of the most laborious employments I could fly to when under bodily and, of course, mental sickness, for it is not impossible I might, instead of making inquiry about my little precious grand-nephew, and the young *ladies*, who play, sing and sew so prettily, write, 'Oh! my back, O! I have the cramp here, there,' etc." She is nearing the end of life, "going many nights to bed without the hope of seeing another day." But the old spirit of drollery, and the lifelong love of science are constantly flashing out. "I could not live without that little business of keeping my accounts," she writes, and shows herself true to a woman's household-place, and to science at the same time. "I hope people in England will never go such lengths in foolery as they do here." At Christmas time, "Cooks and housemaids present one another with knitted bags and purses, the cobbler's daughter embroidered neck-cushions for her friend the butcher's daughter, which are made up by the upholsterer at great expense, lined with white satin, the upper part, on which the back is to rest, is worked with gold, silver, and pearls." And, drollest of all, she adds, "Writing this, puts me in mind that I never could remember the multiplication table, but was obliged to carry always a copy of it about me."

A last gratification, and certainly not the least of the many she enjoyed during her retirement, was the placing in her hands of her nephew's completion in South Africa of his father's survey of the heavens.

It was a work of devotion to a father's memory and greatness, executed with untiring zeal and sometimes at the risk of broken bones. She was unable to read this record of the splendid work her nephew accomplished, when four years of laborious research, and a longer period of study were at last crowned with presenting to the world a book, of which "it may be safely said, that no single publication, during the last century, has made so many and such considerable additions to our knowledge of the constitution of the heavens." What she could not read herself, another read for her, as her nephew recommended when he sent her a copy of the work.

As the end of life and activity drew nearer, there is no longer the same desire to live she felt in previous years: "I have been very ill and confined to my room now three weeks, but it seems the Destroying Angel has passed away, at which I am very glad, because I wish to be a little better prepared for making my exit than I am at present." She was then eighty years of age. A few years later she began to feel more keenly the sadness of life, and the longing for something better than it ever gives. Many of the best and brightest minds have felt as she felt when she wrote these words: "The whole of yesterday I had no other prospect but that it would have been the last of the days of sorrow, trouble and disappointment I have spent from the moment I had any recollection of my existence, which is from between my third and fourth year. . . . In the night I fell out of one fainting fit into another, and when I came to my recollection, between six and seven in the morning, I found Dr. G. sitting before me talking loud in his usual nonsensical

way. Him had Betty called in her fright, for his wife (who is of use to nobody) is gone to spend the summer months in the country." Even in the presence of death and in the ninetieth year of her age, the old spirit of drollery gives piquancy to her views of men and women. In committing to paper her last reflections on the disappointments of life, she writes: You "will see what a solitary and useless life I have led these seventeen years, all owing to not finding Hanover, nor *any one* in it, like what I left, when the best of brothers took me with him to England in August, 1772!" In reality it was she herself, dissatisfied with earth, who was longing for something better than earth can give. She tells us what it was in the epitaph that she wrote on herself, and that was graven on her tomb:—

Here rests the earthly exterior of
CAROLINA HERSCHEL,
Born at Hanover, March 16, 1750,
Died January 9, 1848.

The eyes of Her who is glorified were here below turned to the starry Heavens. Her own Discoveries of Comets, and her participation in the immortal Labours of her Brother, William Herschel, bear witness of this to future ages.

The Royal Irish Academy of Dublin and the Royal Astronomical Society of London enrolled Her name among their members.

At the age of 97 years 10 months she fell asleep in calm rest and in the full possession of her faculties, following into a better Life her Father, Isaac Herschel, who lived to the age of 60 years 2 months 17 days, and lies buried not far off, since the 29th of March 1767.

Were it not for the unquestionable authority with which it comes to us that she wrote this account of her death with her own hand, we might be disposed to

feel the same doubts about the authorship, that critics generally feel about the authorship of the last chapter of the Book of Deuteronomy, in which Moses is commonly supposed to have recorded his own death and funeral. And thus closes the wonderful story of William Herschel and his sister Caroline, the story of the fairy prince of science coming to the sleeping princess of the heavens to awake her and all her company from the sleep of ages on the one hand, and, on the other, the story of the despised household drudge, Cinderella, taking a place, a deserved place, among the laurelled benefactors of humanity. Future ages are certain to witness many histories of men and women, of fairy princes and ragged Cinderellas, uniting perseverance to genius, prosaic detail to lofty imaginings. Other women since her time have shrined their names as worthy travellers among the stars; but, while they may never eclipse the brightness of the sunshine I have endeavoured to picture in this little book, Encke's homage will be echoed by all time—"A lady whose name is so intimately connected with the most brilliant astronomical discoveries of the age, and whose claims to the gratitude of every astronomer will be as conspicuous as her own exertions for extending the boundaries of our knowledge, and for assisting to develop the discoveries by which the name of her great brother has been rendered so famous throughout the literary world."

APPENDIX

(PAGE 44)

IN the short notice of his early life communicated by Herschel in 1783 to the editor of the Göttingen *Magazine of Science and Literature*, Herschel says little of that part of his residence in England which preceded his discovery by Dr. Watson in 1779. What he does say may be summed up in his own words:—

I remained "in the army, however, until I reached my nineteenth year [1757], when I resigned and went over to England. My familiarity with the organ, which I had carefully mastered previously, soon procured for me the position of organist in Yorkshire, which I finally exchanged for a similar situation at Bath in 1766, and while here the peculiar circumstances of my post, as agreeable as it was lucrative, made it possible for me to occupy myself once more with my studies, especially with mathematics."[1] "A similar situation at Bath in 1766" seems to refer to the Octagon Chapel, and is so stated in his sister's *Memoirs*. But there are serious objections to this account of his removal from Halifax to Bath.

In October 1822 there appeared in the *New Monthly Magazine*, of which Thomas Campbell, the poet, was then editor, an obituary notice of Herschel, which gave another and a fuller version of his removal to Bath. Unfortunately,

[1] Professor Holden, *Life and Works of Sir William Herschel*, p. 4.

though the admiration and friendship of the poet for the astronomer are well known, it contains mistakes in dates, otherwise ascertained. "He was master of the band of a regiment which was quartered at Halifax in the year 1770" may be true, but "where he continued for many years" cannot be correct. It may also be true, though it seems to conflict with Southey's story, that he obtained the post of organist for the newly erected organ in that town through the influence of Joah Bates, son of the parish clerk. The story then proceeds: "Disliking the monotony of a country town, he removed with his brother to Bath, where they were both engaged for the Pump-room band by the late Mr. Linley, who then conducted the first musical entertainments established in that city, and where the delightful warblings of his siren daughters, Mrs. Sheridan and Mrs. Tickel, will ever be remembered. Sir William was, like his nephew Griesbach, esteemed an excellent performer on the oboe, as his brother was on the violoncello."

This connection of Linley with Herschel is not referred to by Caroline in her *Memoirs*. But it derives importance from the fact that, according to her testimony, there were, or seem to have been, disagreeable passages between them. At any rate there is good reason to believe that Herschel did not remove from Halifax to Bath, as has generally been given out, to become organist in the Octagon Chapel in 1766. "The Chapel was built in 1766, and opened for divine service in December 1767." Herschel had been more than a year in Bath at that time; he had also been giving concerts on his own account, as his sister gives us distinctly to understand, and on January 3, 1767, he returns thanks, through the *Bath Chronicle*, to the company who did him the honour of attending his concert.[1] He informs them at the same time that he teaches the guitar as well as singing, and takes

[1] I am indebted for these facts to the kindness of Mr. Sturge Cotterell, of Bath.

pupils for the harpsichord and violin. That one of the principal members of the Pump-room band should be appointed organist in the newly erected Octagon Chapel is most likely, and he seems to have occupied the post for about nine years. "He took great delight in a choir of singers who performed the cathedral service at the Octagon Chapel, for whom he composed many excellent anthems, chants, and psalm tunes." Caroline Herschel adds: "This anthem was left with the rest of my brother's sacred compositions, which were left in trust with one of the choristers. . . . All is lost. . . . With difficulty, many years after, one Te Deum was recovered, and when I was in Bath in 1800 I obtained two or three torn books of odd parts." It is difficult to understand why the compositions were left at all, still more to understand what Mr. Linley had to do with the matter, for "the chorister's wife openly charged Mr. Linley with having taken possession of these treasures." [1]

The story in Campbell's magazine proceeds: "Sir William pursued his profession at Bath for some years, highly esteemed by a numerous circle of friends, and increasing in fame and fortune." Whether this was fact or poetic licence may be matter of debate; but the words attributed by the writer to King George III., that "Herschel should not sacrifice his valuable time to crotchets and quavers," may justly be accepted as genuine. And the two sentences with which the notice concludes go far to prove that the writer of it was the poet-editor himself: "Sir William possessed 'the milk of human kindness' in an eminent degree, and was most anxious to gratify his numerous visitors by explaining 'the complicated machinery of his mind' in the simplest manner possible. No one ever returned from his hospitable cottage without feeling gratified with the urbanity of the man, and improved by the productions of his genius."

A relic of these early days is still preserved at Bath in the

[1] *Memoirs*, note at p. 36.

pieces of the organ on which Herschel played, and which may again be erected as a memorial of the great astronomer in the city that was the birthplace of his fame.

Evidently Herschel's views of the heavens left an abiding impression on Campbell's mind.[1] Eighteen years after his first meeting with Herschel, and nine after the astronomer's death, he became acquainted with Pond, then Astronomer-Royal, whose "most interesting and instructive" conversation he likens to "a gift from Providence." He then proceeds to say: "I had lately been dabbling in the astronomical relics of the Greek Alexandrian school, and had the idea of embodying my notes on ancient geography into a regular history, when this *Life of Mrs. Siddons* suspended my intention. But I have of late been so interested in the subject, that I revised my mathematics, the better to understand the histories of ancient science given by Ideler and Delambre. Mr. Pond's conversation has been, therefore, eagerly sought by me,—and he is most affably communicative.

"We have just been gazing on Jupiter and his moons, through a glass that makes Jove appear as large as the sun's disk, and his satellites like ordinary stars! The moon appears through it as large as a church. His opinion of her ladyship is that she is *not* inhabited—there being no atmosphere—and the whole region, probably, only ice and snow. Strange enough that a body, which creates such lively crotchets in so many human brains, should itself be cold and lifeless."

Campbell's poetry, whether in prose or verse, would probably have been more worth reading than Dr. Burney's astronomical poem, but neither of them ever saw the light of day. One thing Campbell relates. Mrs. Pond, he says, "when I first saw her, as she was walking—shortly after their marriage—was a young, fair, and graceful woman, arm in arm with her very plain and elderly husband. There was

[1] See above, pp. 207-9. [2] Beattie, *Life of Campbell*, iii. 94.

an epigram in the newspaper about them. Mr. Pond had published some remarks on the planet 'Venus,' and the wit asked him, 'Why he troubled himself about Venus in the skies, when he had got Venus beside him on earth?'"

The enthusiasm shown in Campbell's account of his interview with Herschel, however, does not appear to have been so lasting as could be wished. In his lines "To the Rainbow," written six years after, in 1819, he says—

> "When Science from Creation's face
> Enchantment's veil withdraws,
> What lovely visions yield their place
> To cold material laws!"

The idea, like the feet in the last line, is somewhat halting.

INDEX

Amici, 121.
Asteroids, 72, 191.

Banks, Sir Joseph, 111, 239.
Bath, as seen by Smollett, 2; by Horace Walpole, 46.
,, housekeeping at, 33.
Brewster, Sir David, 102, 234.
Bulman (Leeds), 33.
Burney, opinion of Jacob Herschel, 32.
,, visit to Slough, 201.
Burney (Fanny), Windsor gossip, 197.

Campbell, interview with Herschel, 206.
,, *New Monthly Magazine*, 257.
Catalogues of stars, 133, 227.
Comets, 193.

Dollond, 109.

Eighteenth century, 41.
Equerries at Windsor, 60.
Eros, discovery of, 71.
Error, limits of, 53.

Facio Duillier, eclipse of 1706, 61.
Ferguson's *Astronomy*, 43.
Fraunhofer, 99, 127.

Galileo, 99, 107.
Gauges of stars, 141.
George III., a lover of astronomy, 84.
,, delays in dealing with Herschel, 90.
,, Triumvirate, 239.
Georgium Sidus, 75.
Glasgow, visits to, 204.
Greenwich Observatory, 52.
,, instruments, 88.

Halley, eclipse of 1715, 63.
,, flattery to Charles II., 77.
Hanover, society in, 34, 251.
Harding, asteroid Juno, 72.
Herschel, Caroline Lucretia, 3.
,, relations towards her brothers, 3.
,, Cinderella, 6, 255.
,, a concert singer, 28.
,, not successful, 32, 38.
,, in England, 29.
,, word-portrait of her, 30, 250.
,, the Lady's Comet, 81.
,, her pension, 81; unpaid, 114.
,, honours paid to her, 243.
,, view of Lives of her brother, 247.
,, life in Hanover, 251.
,, views on servants and workpeople, 34, 115, 252.
Herschel, Sir John F., decline of science in England, 97.
,, distance of stars, 245.
,, Cape of Good Hope, 249.

Herschel, Sir William, birth, 3.
,, father of, 6.
,, mother's foolishness, 8, 9, 18, 21.
,, schooldays of, 11.
,, knowledge of languages, 12.
,, musical and mechanical ability, 13.
,, astronomy, 14.
,, visit to England, 16.
,, flight from Hanover, 19.
,, engagements in England, 24, 257.
,, visit to Italy, 26.
,, removes to Bath, 27.
,, gives concerts there, 27, 258.
,, appointed to Octagon Chapel, 28, 258.
,, race for fame, 32.
,, work in Bath, 35.
,, drought by day, frost by night, 39.
,, discovery of, 47.
,, aims in observing, 53.
,, length of earth's day, 66.
,, "Account of a Comet," 68.
,, Uranus, 73.
,, *Catalogue of Double Stars*, 80.
,, contributions to *Phil. Trans.*, 81.
,, Copley Medal, 84.
,, public opinion, 85.
,, summoned to court, 86.
,, "showman of the heavens," 89.
,, no honour bestowed till 1816, 94.
,, encouragement of science, 96.
,, disparagement of his work, 101, 222.
,, King's Astronomer, 103.
,, polishing his great mirror, 112.
,, his ingenuity, 117.
,, accidents, 119.
Herschel, requiem of telescope, 125.
,, reviews of the heavens, 129.
,, simplicity and kindness, 209, 259.
,, failing health, 210.
,, religious sentiments, 215.
,, Arago's eulogium, 217.
Huggins, Sir William, 229.

Jupiter, 175.

Keats, 91.

Laboratories of universe, 139.
Lalande, 40, 51, 58, 77, 88, 105.
Linley, Pump-room band, 27, 258.
,, his daughter's singing, 28.

Mars, 173.
Maskelyne, honoured by the French, 86.
Mercury, 168.
Messier, 111.
Micrometer, 80.
Milky Way, 143, 233.
Moon, mountains, 54.
,, volcanoes, 56.
,, atmosphere, 60.
More, Hannah, 29.

Napoleon, 207.
Nebulæ, relative antiquity, 147.
,, resolvable and gaseous, 228.
Nebular hypothesis, 235.
Newton, encouragement to, 97.
,, his telescope, 107.
Niemeyer, 26.

Olbers, discovery of asteroids, 72.
,, absorption of light by ether, 147.

Pfaff, 248.
Piazzi, 72, 119.
Points and blunts, war of, 51.
Pringle, Sir John, 51.

Rosse, Lord, 121.

Saturn, 176.
Schroeter, 169.
Stannyan, Captain, 60.
Stars, periodical, 51.
,, changes among, 130.
,, double, 219.
,, spectra of, 226.
,, growth of, 227.
,, unity of design in, 228.
,, distance of, 245.
Southey, story of Herschel, 25, 257.
Sun, total eclipses of, 1706, 1715, 61.
,, corona and red flames of, 62.
,, movements, 135.
,, spectrum of, 157.
Sun, heat, light, and chemical rays, 159.
,, spots, 161.

Telescope, price-catalogue in 1771, 105.
,, sales of, 122.
,, refractors, 111, 127.
Triumvirate, the, 239.

Uranus, 186.

Venus, 169.

Walpole, 46, 151.
Watson, William, and William Watson, jun., 47.

PRINTED BY
MORRISON AND GIBB LIMITED
EDINBURGH

THE WORLD'S EPOCH-MAKERS.

A Series of Biographical Studies dealing with Prominent Epochs in Theology, Philosophy, and the History of Intellectual Development.

EDITED BY OLIPHANT SMEATON.

Each Volume contains on an average 250 pages, and is published at 3s. The Volumes will *not* appear in strict chronological sequence.

I. BUDDHA AND BUDDHISM. The First Bursting of the Fetters of Ignorance and Superstition. By ARTHUR LILLIE, M.A., London.
[*Now ready.*

II. SOCRATES. The Moral Awakening of the Western World. By Rev. J. T. FORBES, M.A., Edinburgh.

III. PLATO AND ARISTOTLE. A Contrast and an Appreciation. By Professor D. G. RITCHIE, M.A., University of St. Andrews.

IV. MARCUS AURELIUS AND THE LATER STOICS. The Last and the Greatest Age of Stoicism. By F. W. BUSSELL, D.D., Vice-Principal of Brasenose College, Oxford.

V. ORIGEN AND GREEK PATRISTIC THEOLOGY. By Rev. W. FAIRWEATHER, M.A.

VI. AUGUSTINE AND LATIN PATRISTIC THEOLOGY. By Rev. Professor B. B. WARFIELD, D.D., Princeton.

VII. MAHOMET AND MAHOMETANISM. By P. DE LACY JOHNSTONE M.A.(Oxon.).

VIII. ANSELM AND *CUR DEUS HOMO*. By Rev. A. C. WELCH, B.D.

IX. FRANCIS AND DOMINIC—THE FOUNDERS OF THE MENDICANT ORDERS. Monasticism and its Reform. By Rev. Professor J. HERKLESS, D.D., University of St. Andrews.

X. SCOTUS ERIGENA AND HIS EPOCH. By R. LATTA, Ph.D., D.Sc., Professor of Moral Philosophy in the University of Aberdeen.

XI. WYCLIF AND THE LOLLARDS. By Rev. J. C. CARRICK, B.D.

XII. THE MEDICI AND THE ITALIAN RENAISSANCE. By OLIPHANT SMEATON, M.A., Edinburgh.

[*Continued on next page.*

THE WORLD'S EPOCH-MAKERS—*continued.*

XIII. THE TWO BACONS AND EXPERIMENTAL SCIENCE. Showing how ROGER BACON prepared the way for FRANCIS BACON, LORD VERULAM. By Rev. W. J. COUPER, M.A.

XIV. SAVONAROLA. By Rev. G. M'HARDY, D.D.

XV. LUTHER AND THE GERMAN REFORMATION. By Rev. Professor T. M. LINDSAY, D.D., F.C. College, Glasgow. [*Now ready.*

XVI. CRANMER AND THE ENGLISH REFORMATION. By A. D. INNES, M.A.(Oxon.), London. [*Now ready.*

XVII. CALVIN AND THE REFORMED THEOLOGY. By Rev. Principal SALMOND, D.D., F.C. College, Aberdeen.

XVIII. PASCAL AND THE PORT ROYALISTS. By Professor W. CLARK, LL.D., D.C.L., Trinity College, Toronto.

XIX. DESCARTES, SPINOZA, AND THE NEW PHILOSOPHY. By Rev. Professor J. IVERACH, D.D., F.C. College, Aberdeen.

XX. THE HERSCHELS. By JAMES SIME, M.A. [*Now ready.*

XXI. WESLEY AND METHODISM. By F. J. SNELL, M.A.(Oxon.). [*Now ready.*

XXII. LESSING AND THE NEW HUMANISM. Including Baumgarten and the Science of Æsthetics. By Rev. A. P. DAVIDSON, M.A.

XXIII. HUME AND HIS INFLUENCE ON PHILOSOPHY AND THEOLOGY. By Professor J. ORR, D.D., Edinburgh.

XXIV. ROUSSEAU AND NATURALISM IN LIFE AND THOUGHT. By Professor W. H. HUDSON, M.A., Leland Stanford Junior University, California.

XXV. KANT AND HIS PHILOSOPHICAL REVOLUTION. By Professor R. M. WENLEY, D.Sc., Ph.D., University of Michigan.

XXVI. SCHLEIERMACHER AND THE REJUVENESCENCE OF THEOLOGY. By Professor A. MARTIN, D.D., New College, Edinburgh.

XXVII. HEGEL AND HEGELIANISM. By Professor R. MACKINTOSH, D.D., Lancashire Independent College, Manchester.

XXVIII. NEWMAN AND HIS INFLUENCE. By C. SAROLEA, Ph.D., Litt. Doc., University of Edinburgh.

DR. STALKER'S WORKS.

In Crown 8vo, Large Type Edition, 3s. 6d.;
Cheaper Edition, 1s. 6d.,

1. THE LIFE OF JESUS CHRIST.

By Rev. JAMES STALKER, D.D.

'No work since "Ecce Homo" has at all approached this in succinct, clear-cut, and incisive criticism on Christ as He appeared to those who believed on Him.'—*Literary World.*

'A vivid, picturesque style is the one thing which never grows old or loses its charm. The notes have been carefully revised and brought up to date, the best literature which has appeared since its first issue being skilfully noted. This new edition should be got and placed beside the old. It is one of the few books of which we may afford to have two copies.'—*Expository Times.*

'Even with all our modern works on this exhaustless theme, from Neander to Farrar and Geikie, there is none which occupies the ground of Dr. Stalker's. . . . We question whether any one popular work so impressively and adequately represents Jesus to the mind.'—*Christian.*

Uniform with the above in Size and Price,

2. THE LIFE OF PAUL.

By Rev. JAMES STALKER, D.D.

'Surpassingly excellent. . . . Dr. Stalker gives a masterly miniature, and thousands will see more of Paul in it than in the life-sized portraits. . . . He has the gift of vivid writing; he sketches and colours with words; he does more, he vivifies persons and scenes by his inspiring sentences. Those who wish to pursue the subjects of study suggested by the noble career of Paul, will here find ample guidance for their more thorough research. We have not seen a handbook more completely to our mind.'—C. H. SPURGEON in *Sword and Trowel.*

'A gem of sacred biography.'—*Christian Leader.*

'We cannot speak too highly of the way in which our author has handled his material. . . . Dr. Stalker, as in his "Life of Christ," becomes thoroughly original in his treatment, and we have a feeling that what we are reading is not only new, but true.'—*Ecclesiastical Gazette.*

WORKS BEARING ON THE
LIFE AND PERSON OF CHRIST,

PUBLISHED BY

T. & T. CLARK, 38 GEORGE STREET, EDINBURGH.

Adamson (*T., D.D.*)—*Studies of the Mind in Christ. Post* 8vo, 4s. 6d.

Andrews (*Rev. S. J.*)—*The Life of Our Lord upon the Earth:* Considered in its Historical, Chronological, and Geographical Relations. New Edition, thoroughly revised. The only Authorised Edition in this Country. Demy 8vo, 9s.

Bruce (*A. B., D.D.*)—*The Kingdom of God; or, Christ's Teaching* according to the Synoptical Gospels. Sixth Edition, post 8vo, 7s. 6d.
'A remarkable book.'—*Saturday Review.*

Bruce (*A. B., D.D.*)—*The Training of the Twelve. Fifth Edition,* 8vo, 10s. 6d.
'A volume which can never lose its charm either for the preacher or for the ordinary Christian reader.'—*London Quarterly Review.*

Bruce (*A. B., D.D.*)—*The Humiliation of Christ. Fourth Edition,* 8vo, 10s. 6d.
'This noble theological treatise.'—*Evangelical Magazine.*

Candlish (*Prof. J. S., D.D.*)—*The Christian Salvation. Lectures on* the Work of Christ: Its Appropriation and its Issues. 8vo, 7s. 6d.

Caspari (*C. E.*)—*A Chronological and Geographical Introduction to* THE LIFE OF CHRIST. 8vo, 7s. 6d.
'No Bible student should fail to make this treatise his constant friend and companion.'—*Bell's Weekly Messenger.*

Caspers (*A.*)—*The Footsteps of Christ. Crown* 8vo, 7s. 6d.

Dorner (*Professor*)—*History of the Development of the Doctrine of* THE PERSON OF CHRIST. Five vols. 8vo, £2, 12s. 6d.

Forrest (*D. W., D.D.*)—*The Christ of History and of Experience.* Second Edition, 8vo, 10s. 6d.

Hall (*Newman, D.D.*)—*The Lord's Prayer: A Practical Meditation.* Second Edition, crown 8vo, 4s. 6d.
'The author's thoughts are sharply cut, and are like crystals in their clearness and power.'—*British Quarterly Review.*

Hall (*Newman, D.D.*)—*Gethsemane: Leaves of Healing from the* Garden of Grief. Crown 8vo, 4s.
'Richly laden with consolation for the afflicted children of God; and from the first page to the last it does not strike one false note.'—*Christian Leader.*

Innes (*A. Taylor*)—*The Trial of Jesus Christ: A Legal Monograph.* Post 8vo, 2s. 6d.

Krummacher (*Dr. F. W.*)—*The Suffering Saviour. Crown* 8vo, 7s. 6d.
'To the devout and earnest Christian the volume will be a treasure indeed.'—*Wesleyan Times.*

[*Continued on next page.*

Lange (J. P., D.D.)—The Life of Our Lord Jesus Christ. Edited, with additional Notes, by Prof. MARCUS DODS, D.D. Second Edition, in Four Vols. 8vo, Subscription price, 28s.

Lehmann (Pastor E.)—Scenes from the Life of Jesus. Cr. 8vo, 3s. 6d.

'There is in these lectures a tender sympathy, and a spiritual devoutness and simplicity, which gives to them a real charm.'—*Literary World.*

Lilley (J. P., M.A.)—The Lord's Supper: Its Origin, Nature, and Use. Crown 8vo, 5s.

'We know no better modern book more suggestive and helpful.'—*Freeman.*

Muirhead (Rev. L. A., B.D.)—The Times of Christ. (Bible Class Handbooks.) 2s.

Naville (Ernest)—The Christ. Translated by Rev. T. J. Després. Crown 8vo, 4s. 6d.

Nicoll (W. R., LL.D.)—The Incarnate Saviour: A Life of Jesus Christ. New Edition, crown 8vo, 3s. 6d.

'It commands my warm sympathy and admiration.'—*Canon Liddon.*

Ross (C., M.A.)—Our Father's Kingdom: Lectures on the Lord's Prayer. Crown 8vo, 2s. 6d.

Salmond (Principal)—The Life of Christ. Bible Class Primers. Paper covers, 6d.; cloth, 8d.

Scrymgeour (Wm.)—Lessons on the Life of Christ. Bible Class Handbooks, 2s. 6d.

'A thoroughly satisfactory help to teacher and scholar.'—*British Messenger.*

Stalker (Jas., D.D.)—A Life of Christ. Bible Class Handbooks. Crown 8vo, 1s. 6d.; large type Edition, handsomely bound, 3s. 6d.

Steinmeyer (Dr. F. L.)—The Miracles of Our Lord: Examined in their Relation to Modern Criticism. 8vo, 7s. 6d.

Steinmeyer (Dr. F. L.)—The History of the Passion and Resurrection OF OUR LORD, in the Light of Modern Criticism. 8vo, 10s. 6d.

'Will well repay earnest study.'—*Weekly Review.*

Stier (Dr. Rudolph)—On the Words of the Lord Jesus. Eight vols. 8vo (or the Eight vols. bound in FOUR), £2, 2s. *net.* Separate volumes may be had, price 10s. 6d.

'The whole work is a treasury of thoughtful exposition.'—*Guardian.*

Weiss (Dr. Bernhard)—The Life of Christ. Three vols. 8vo, 31s. 6d.

'From the thoroughness of the discussion and clearness of the writer, we anticipate a very valuable addition to the Great Biography.'—*Freeman.*

Wendt (Prof. H. H.)—The Teaching of Jesus. Two vols. 8vo, 21s.

'A brilliant and satisfactory exposition of the teaching of Christ.'—*Expositor.*

The Voice from the Cross: A Series of Sermons on Our Lord's Passion, by Eminent Living Preachers of Germany. Edited and Translated by WM. MACINTOSH, M.A., F.S.S. Crown 8vo, 5s.

'It is certain to be welcomed with devout gratitude by every evangelical Christian in Britain.'—*Christian Leader.*

A GREAT BIBLICAL ENCYCLOPÆDIA.

'If the other volumes come up to the standard of the first, this Dictionary seems likely to take its place as the standard authority for biblical students of the present generation.'—*Times.*

To be Completed in Four Volumes, imperial 8vo (of nearly 900 pages each).
Price per Volume, in cloth, 28s.; in half morocco, 34s.,

A DICTIONARY OF THE BIBLE,

Dealing with its Language, Literature, and Contents, including the Biblical Theology.

Edited by JAMES HASTINGS, M.A., D.D., with the Assistance of J. A. SELBIE, M.A., and, chiefly in the Revision of the Proofs, of A. B. DAVIDSON, D.D., LL.D., Edinburgh; S. R. DRIVER, D.D., Litt.D., Oxford; and H. B. SWETE, D.D., Litt.D., Cambridge.

Full Prospectus, with Specimen Pages, from all Booksellers, or from the Publishers.

'We offer Dr. Hastings our sincere congratulations on the publication of the first instalment of this great enterprise. . . . A work was urgently needed which should present the student with the approved results of modern inquiry, and which should also acquaint him with the methods by which theological problems are now approached by the most learned and devout of our theologians.'—*Guardian.*

'We welcome with the utmost cordiality the first volume of Messrs. Clark's great enterprise, "A Dictionary of the Bible." That there was room and need for such a book is unquestionable. . . . We have here all that the student can desire, a work of remarkable fulness, well up to date, and yet at the same time conservative in its general tendency, almost faultlessly accurate, and produced by the publishers in a most excellent and convenient style. We can thoroughly recommend it to our readers as a book which should fully satisfy their anticipations. . . . This new Dictionary is one of the most important aids that have recently been furnished to a true understanding of Scripture, and, properly used, will brighten and enrich the pulpit work of every minister who possesses it. . . . We are greatly struck by the excellence of the short articles. They are better done than in any other work of the kind. We have compared several of them with their sources, and this shows at once the unpretentious labour that is behind them. . . . Dr. A. B. Davidson is a tower of strength, and he shows at his best in the articles on Angels, on Covenant (a masterpiece, full of illumination), and on Eschatology of the Old Testament. His contributions are the chief ornaments and treasure-stores of the Dictionary. . . . We are very conscious of having done most inadequate justice to this very valuable book. Perhaps, however, enough has been said to show our great sense of its worth. It is a book that one is sure to be turning to again and again with increased confidence and gratitude. It will be an evil omen for the Church if ministers do not come forward to make the best of the opportunity now presented them.'—EDITOR, *British Weekly.*

'Will give widespread satisfaction. Every person consulting it may rely upon its trustworthiness. . . . Far away in advance of any other Bible Dictionary that has ever been published in real usefulness for preachers, Bible students, and teachers.'—*Methodist Recorder.*

'This monumental work. It has made a great beginning, and promises to take rank as one of the most important biblical enterprises of the century.'—*Christian World.*

EDINBURGH: **T. & T. CLARK,** 38 GEORGE STREET.